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MELBOURNE

THE ECOLOGY OF LICE ON SHEEP

I. THE INFLUENCE OF SKIN TEMPERATURE ON POPULATIONS OF LINOGNATHUS PEDALIS (OSBORNE)

By M. D. Murray*

[*Manuscript received March* 3, 1960]

Summary

Female *Linognathus pedalis* (Osborne) were exposed to temperatures of 22, 25, 30, 36, and 40°C. Most eggs were laid at 36°C but none at 22°C. Eggs were exposed to 22, 25, 30, 33, 36, 38, and 40°C and hatched only at 33, 36, and 38°C. Most eggs hatched at 36°C.

At 36°C, however, few eggs were laid at 100 per cent. R.H. and the majority of eggs exposed to even 92 per cent. R.H. failed to hatch. Thus, high humidities could reduce the number of eggs which are laid and which hatch on the legs of sheep even if the temperature near the skin is favourable.

When sheep were exposed to atmospheric temperatures near 28°C the temperatures near the skin of the body were higher than 38°C, and conditions cool enough for the maintenance of *L. pedalis* populations were found only on parts of the legs. On exposure to cold, the temperature near the skin of the legs fell and remained too cold for oviposition and egg development during several hours of exposure. However, it was also found that the resultant temperatures near the skin of the legs of the same sheep and of the legs of different sheep could differ greatly. Thus, those legs on which temperatures near the skin are above 30°C for the longest periods may become most heavily infested.

These findings offer a possible explanation of observed differences in the numbers of *L. pedalis* on the legs of sheep.

I. Introduction

The common name of *Linognathus pedalis* (Osborne) is the foot louse of sheep and refers to its characteristic distribution. These lice are most abundant in the spring, when they may spread up the legs and occasionally infest the belly (Scott 1950). Infestation of the scrotum of rams is frequent, but the sides and back of the sheep rarely become infested. Variations in the degree of infestation of the legs of the same sheep may occur (Murray, unpublished data).

When sheep are exposed to cold, the skin temperature of the legs may drop from temperatures which approximate the temperature of the body to only slightly higher than the temperature of the surrounding air (Murray 1957*b*). Thus the microclimate of the habitat of *L. pedalis* can change considerably. Investigations were undertaken therefore to determine whether these changes could influence the numbers of *L. pedalis*.

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II. Influence of Temperature and Humidity on Oviposition

The same techniques were used as in the studies on the oviposition behaviour of other species of lice (Murray 1957*a*).

Lice, together with glass wool, were placed in cells along which a temperature gradient of 20–40°C was established. All of the 53 eggs laid were attached to the glass wool in the temperature zone 35–39°C and all, except five, were laid with the end attachment towards the warm end of the gradient. The eggs laid by other foot lice, which were placed in similar cells with glass wool and exposed to a uniform temperature of 36°C, were distributed throughout the cells and aligned along the fibre in either direction. Thus, *L. pedalis* was attracted to warmth and the eggs were aligned along the fibre according to the direction of the temperature gradient.

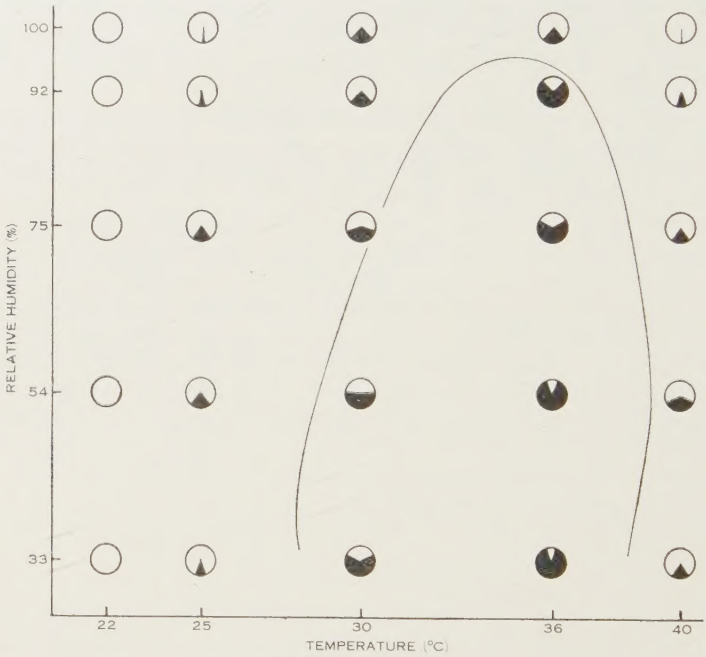

Fig. 1.—Influence of temperature and humidity on oviposition of *L. pedalis*. The black area within each circle represents the number of eggs laid per 100 females. The line encloses combinations of temperature and R.H. at which more than 50 per cent. of the eggs were laid.

The behaviour of the lice at the time of oviposition was similar to that of *L. stenopsis* (Burm.) (Murray 1957*a*) in that, initally, they moved to the warm end of the cell where they rested with their head pointed towards the warm end. Then they turned about, grasped a fibre with their gonopods, and laid the egg.

Female lice were divided into 25 equal groups, each of which was placed in a glass tube with hair from the leg of a sheep. Five groups were exposed to each of the following temperatures: 22, 25, 30, 36, or 40°C, and one group of each lot of five was

exposed to 33, 54, 74, 92, and 100 per cent. R.H. About 80 lice were exposed to each of the 25 different combinations of temperature and humidity. No eggs were laid at 22°C, most eggs were laid at 36°C, more were laid at 30°C than at 40°C, and exposure to 100 per cent. R.H. resulted in a decrease in the number laid at 36°C (Fig. 1).

III. Influence of Temperature and Humidity on the Development of Eggs

In order to collect eggs of known age, females were removed from a heavily infested sheep and exposed to a temperature of 36°C and to 54 per cent. R.H. Glass wool was provided for egg attachment and after 24 hr the eggs were removed.

As it was not possible to collect sufficient eggs to expose to all temperature and humidity conditions each day, the eggs from each collection were divided into five groups, one of which was exposed to 36°C at 54 per cent. R.H. as a control. The

Fig. 2.—Influence of temperature and humidity on the development and hatching of the eggs of *L. pedalis*. The black area within each circle represents the percentage of eggs which hatched.

remaining four groups were placed at 22, 25, 30, 33, 36, 38, or 40°C and at each temperature a group was exposed to 33, 54, 74, or 92 per cent. R.H. At least 40 eggs were exposed to each of these 28 different conditions. After 3 weeks the number which had hatched was counted.

In seven of the eight control groups, 90–100 per cent. of the eggs hatched and in the eighth 84 per cent. The latter, however, was the control for the eggs exposed to 54 per cent. R.H. at 30 and 40°C, conditions at which no eggs hatched. The control groups, therefore, proved comparable and the combined results are presented in Figure 2. It will be seen that at 33 and 36°C the majority of eggs hatched, except at 92 per cent. R.H. At this humidity, there was no embryonic development in *c.* 50 per cent. of the unhatched eggs. No eggs hatched at other temperatures except a few at 38°C.

TABLE 1

SKIN TEMPERATURES (°C) OF ADULT SHEEP EXPOSED TO AN ATMOSPHERIC TEMPERATURE OF *c.* 28°C

Temperatures of the *right* legs are given in italic type

	Merino, Ewe	Merino, Wether	Merino Cross, Wether	Merino, Ewe	Merino Cross, Ewe	Merino, Ewe	Merino, Ewe	Merino, Ewe	Merino, Ewe	Merino Cross, Wether
Body										
No. of readings	17	12	10	10	15	15	15	15	12	15
Mean skin temp. (°C)	38·6	39·0	38·5	38·8	38·9	38·7	39·0	39·4	39·2	39·3
S.D.	±0·24	±0·19	±0·23	±0·39	±0·48	±0·28	±0·17	±0·34	±0·42	±0·25
Fore leg										
Above knee	38·0 *37·1*	38·9 *39·1*	— —	38·0 *37·1*	37·5 *37·5*	38·0 *38·7*	38·7 *37·8*	38·0 *38·7*	39·2 *39·1*	39·4 *38·7*
Knee	37·1 *35·9*	37·3 *36·6*	35·4 —	36·8 *37·3*	36·1 *36·4*	36·4 *38·4*	37·8 *37·1*	37·7 *38·2*	38·9 *38·5*	39·1 *36·3*
Upper metacarpus	36·1 *35·9*	34·7 *37·1*	34·9 *34·7*	35·6 *35·9*	33·8 *34·3*	36·4 *36·6*	36·1 *36·8*	36·4 *36·8*	38·0 *38·5*	36·1 *35·0*
Lower metacarpus	35·9 *35·4*	35·4 *35·2*	— —	35·9 *35·7*	33·5 *<33*	36·8 *35·9*	35·9 *36·8*	35·9 *37·0*	37·7 *38·2*	35·2 *35·4*
Fetlock	35·7 *34·7*	35·6 *35·4*	34·5 *34·7*	35·7 *34·7*	35·4 *<33*	36·1 *35·6*	34·5 *34·7*	35·9 *36·3*	38·4 *37·8*	34·9 *33·6*
Pastern	35·6 *34·5*	— —	— —	35·6 *35·4*	34·9 *<33*	35·9 *35·6*	34·9 *35·6*	35·4 *36·1*	38·4 *38·0*	34·0 *32·9*
Coronary band	34·9 *35·7*	35·4 *35·4*	34·2 *33·5*	35·0 *35·4*	35·0 *<33*	36·4 *35·6*	35·4 *36·4*	36·6 *37·3*	38·5 *37·7*	32·8 *34·3*
Bulb of heel	36·6 *37·3*	— *38·0*	35·4 *35·7*	37·5 *37·1*	36·3 *34·9*	37·3 *37·0*	37·3 *38·4*	37·7 *38·2*	39·4 *38·7*	36·8 *36·8*
Hind leg										
Above hock	37·3 *37·0*	38·9 *38·2*	37·8 *37·8*	37·1 *37·8*	38·0 *38·2*	38·4 *37·3*	38·2 *38·4*	37·8 *37·7*	39·2 *38·9*	38·7 *38·5*
Hock	36·8 *35·9*	38·4 *38·0*	— —	37·8 *37·5*	36·8 *37·1*	38·0 *37·7*	37·7 *37·1*	38·3 *38·0*	38·0 *37·7*	38·7 *37·1*
Upper metatarsus	34·7 *35·7*	37·3 *37·8*	36·2 *35·9*	36·6 *36·3*	34·0 *35·4*	36·3 *37·0*	36·6 *36·3*	37·3 *37·8*	37·7 *37·1*	37·7 *37·5*
Lower metatarsus	— *35·0*	37·3 *37·0*	35·9 *36·3*	37·7 *37·1*	<33 *<33*	36·1 *36·4*	37·0 *36·3*	37·0 *36·3*	37·7 *37·1*	36·8 *37·7*
Fetlock	35·9 *34·7*	37·8 *37·7*	— —	37·7 *37·0*	<33 *<33*	35·6 *36·4*	36·4 *35·6*	36·3 *36·1*	37·3 *37·3*	35·6 *37·1*
Pastern	35·9 *34·7*	— —	— —	37·5 *36·4*	<33 *<33*	35·2 *35·7*	36·3 *36·3*	36·6 *36·6*	37·5 *37·7*	34·9 *35·6*
Coronary band	35·4 *34·3*	35·0 *38·3*	36·6 *37·3*	37·7 *36·8*	<33 *<33*	34·7 36·3	36·1 *37·7*	35·7 *35·4*	38·0 *37·1*	33·6 *34·7*
Bulb of heel	36·8 *36·3*	38·4 *38·4*	37·8 —	37·7 *37·9*	<33 *34·4*	36·8 *37·7*	37·7 *37·7*	36·4 *37·5*	38·5 *38·2*	37·3 *36·8*

Additional groups of *c.* 50 eggs were exposed to the same range of relative humidities at temperatures of 30, 33, 36, and 38°C. The percentage of eggs which hatched was similar to that obtained in the previous experiment. No eggs hatched at 30°C, but some hatched at 38°C at the lower relative humidities. The range of constant temperatures at which the eggs of *L. pedalis* developed was therefore very restricted and the optimum conditions were near 36°C.

IV. Some Factors which Influence the Skin Temperature of the Legs of Sheep

(*a*) *Exposure to Heat*

Ten adult sheep, whose fleeces were *c.* 2 in. thick, were placed in turn in a climate box at an atmospheric temperature of *c.* 28°C (*c.* 82·4°F). After 4 hr, the temperatures next to the skin of the body and limbs were taken with a thermistor-bridge apparatus. The temperature on the body of all sheep was always over 38°C, whereas on the limbs it was usually lower (see Table 1).

(*b*) *Exposure to Cold*

When sheep were exposed to an atmospheric temperature of 10°C, the skin temperature of the legs dropped to within a few degrees of the atmospheric temperature (Murray 1957*b*). The following observations were carried out to determine whether the temperature near the skin of a leg would remain low for several hours continuously.

Thermocouples were attached next to the skin of each pastern and of the midside of the body, and connected to a recording potentiometer. A 12-in. fan was placed about 4 ft from the sheep to blow air directly on to the side of the animal. The temperature of the air of the climate room was lowered from *c.* 22 to *c.* 6°C.

Figure 3 shows the temperature recorded on a 5-yr-old Merino ewe carrying a $2\frac{1}{2}$-in. fleece. The temperature near the skin of the legs remained over 25°C until the air temperature reached *c.* 14°C. Then the temperature of the right fore leg and both hind legs dropped below 25°C and remained below for the following 11 hr, irrespective of whether the animal was standing or lying down. The temperature near the skin of the left fore leg, however, remained over 25°C throughout most of the experimental period. Thus the temperatures near the skin of the individual legs of a sheep can differ considerably. This was further demonstrated with another sheep, from which records were taken of the temperature of the left fore leg and left hind leg only. The temperature near the skin of the hind leg dropped below 25°C only when the animal stood, and even then it was always higher than that of the fore leg. When the long wool covering the pastern of the hind leg was removed, the temperature dropped to nearly that of the fore leg.

There was also considerable variation in the response of different sheep to an atmospheric temperature of *c.* 6°C. The temperature near the skin of the legs of a 5-yr-old crossbred (Dorset×Merino) ewe with a $\frac{1}{2}$-in. fleece dropped below 25°C only when the fan was on, whereas that of a 5-yr-old Merino with a $2\frac{1}{2}$-in. fleece dropped below 25°C in still air.

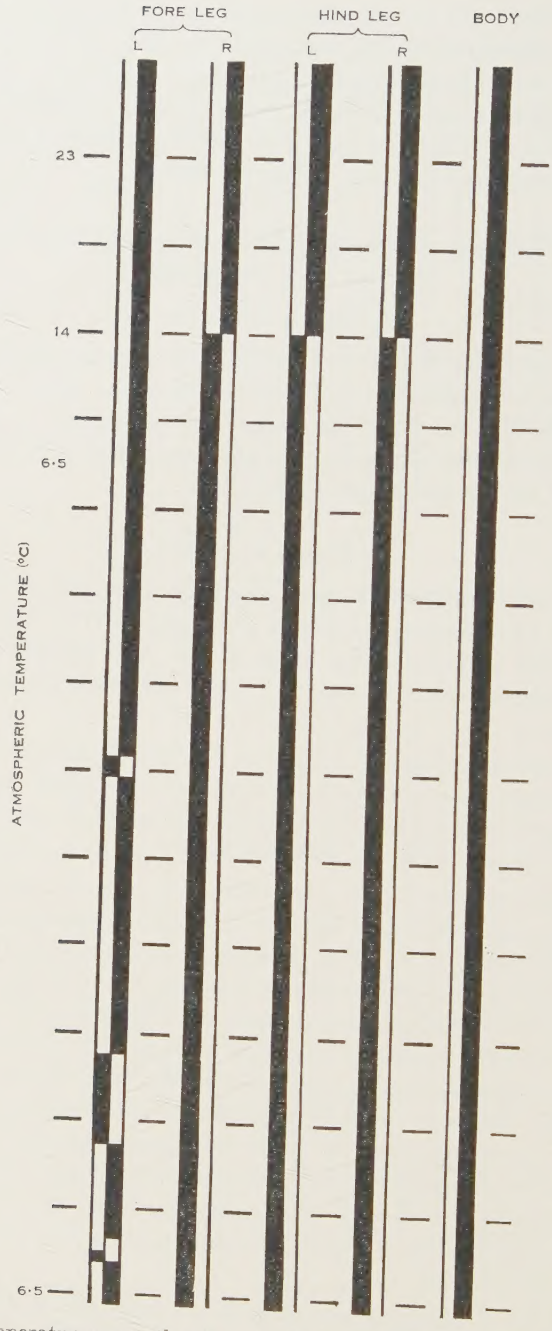

Fig. 3.—Temperatures near the skin of a sheep exposed to a cold atmosphere (°C). Black areas in the right-hand column represent skin temperatures above 25°C and those in the left-hand column represent temperatures of 25°C or lower. Horizontal lines have been drawn at each hour. *L*, left; *R*, right.

V. Discussion

Eggs were laid from 25 to 40°C and the maximum number was laid at 36°C. However, the range of temperatures at which the eggs of *L. pedalis* would develop and hatch was very restricted. None hatched at 30 or 40°C and only a few at 38°C; most eggs hatched at 36°C. At this temperature, however, high relative humidities exerted an adverse influence on oviposition and the development of the eggs of *L. pedalis*. Therefore, should the legs of sheep become frequently soaked, the resultant high humidities near the skin could reduce both the number of eggs which are laid and the number which hatch.

When sheep were exposed to atmospheric temperatures of *c.* 28°C (*c.* 82·4°F), the temperature near the skin of the body was always higher than 38°C, whereas that of the legs was usually lower. Moule and Knapp (1950) showed that the temperature of the skin of the scrotum of rams is invariably lower than that of the skin of the body. Thus, during warm weather the temperatures near the skin are favourable for maintenance of populations of *L. pedalis* on parts of the legs and on the scrotum but they are unfavourable on the body.

The majority of the eggs of the face louse *L. ovillus* (Neumann) hatch at 37·5°C but fail to hatch at 40°C (Murray 1955). The disappearance of this louse from the body of the sheep in hot summers, such as occur in Australia, could be associated also with too high temperatures near the skin of the body. However, the slight differences in the temperature requirements of *L. pedalis* and *L. ovillus* do not explain why the predilection site of one is the leg and of the other is the face.

Studies in the climate room showed that the temperature near the skin of the legs of sheep can remain below the minimal temperature required for both oviposition and egg development for considerable periods. Furthermore, it was found that there could be considerable differences between these temperatures on the legs of a single sheep and on the legs of different sheep. Thus, should the temperatures near the skin of one leg of a sheep be over 30°C more frequently or for longer periods than those of the other legs, then it could become the most heavily infested. Similarly, one sheep could become more heavily infested than another if the temperatures near the skin of its legs were more frequently suitable for oviposition and egg development.

The experimental findings presented demonstrate that the microclimate near the skin of the legs of sheep can change sufficiently to influence the numbers of *L. pedalis*. Should similar changes occur on sheep under normal conditions of husbandry, they offer an explanation of the observed differences in the degree of infestation of sheep with foot lice.

VI. Acknowledgments

I would like to thank Dr. I. W. McDonald, Chief, Division of Animal Physiology, C.S.I.R.O., for permission to use a climate room at the Ian Clunies Ross Animal Research Laboratory, Prospect, N.S.W., and Mr. W. Richardson for operating it.

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THE ECOLOGY OF LICE ON SHEEP

II. THE INFLUENCE OF TEMPERATURE AND HUMIDITY ON THE DEVELOPMENT AND HATCHING OF THE EGGS OF DAMALINIA OVIS (L.)

By M. D. Murray*

[*Manuscript received June* 20, 1960]

Summary

The temperature and humidity requirements for the development and hatching of the eggs of *Damalinia ovis* (L.) were determined.

Morphogenesis of the eggs of *D. ovis* was completed only within the temperature range 30–39°C but the most favourable range was 33–39°C. When development was completed eggs hatched from 22–42·5°C. The majority of embryos within eggs incubated at 33–39°C and maintained at R.H.'s of 7–92 per cent. completed their development but those exposed to 92 per cent. R.H. failed to hatch. An exposure to 92 per cent. R.H. for only the last 24 hr of their development was sufficient to prevent hatching.

I. Introduction

The influence of temperature and humidity on various aspects of the biology of *Damalinia ovis* (L.) has been studied in order to determine the effects of the microclimate of the fleece. It was shown previously that temperatures between 32 and 40°C are required for *D. ovis* to lay eggs and, consequently, the temperature of the skin determines the distribution of the eggs over the body of the sheep (Murray 1957*b*, 1957*c*). The ranges of temperature and humidity within which eggs complete their development and hatch are reported in this paper.

II. Methods

Eggs were obtained by clipping the fleece from infested sheep or by confining females with wool at a temperature of 37°C and 54 per cent. R.H., conditions approximating the optimum for oviposition (Murray 1957*b*). The lice were collected from sheep by the method described previously (Murray 1957*a*).

To facilitate the study, small pieces of wool bearing eggs were held in position on thin white paper by coverslips fixed with cellulose tape. Individual eggs were identified from their position in relation to other eggs and their embryonic development observed with transmitted light.

It was necessary in some experiments to relate the degree of morphogenesis to the age of the egg. Some 50 eggs, 0–18 hr old, were incubated at 37°C and 54 per cent. R.H., conditions within the range of temperature and humidity normally found near the skin of sheep (Frazer 1957; Murray 1957*c*), and examined daily.

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No evidence of morphogenesis was discernible until 2–3 days. At 4 days it was most obvious in the region of the embryo's abdomen which was completely recognizable in 5–6 days. By 8–9 days the whole embryo was formed and the head, thorax, legs, and bristles could be seen easily although they were pale. During the 24 hr before hatching the colour of the embryo darkened to fawn. The majority of the eggs hatched in 10–11 days.

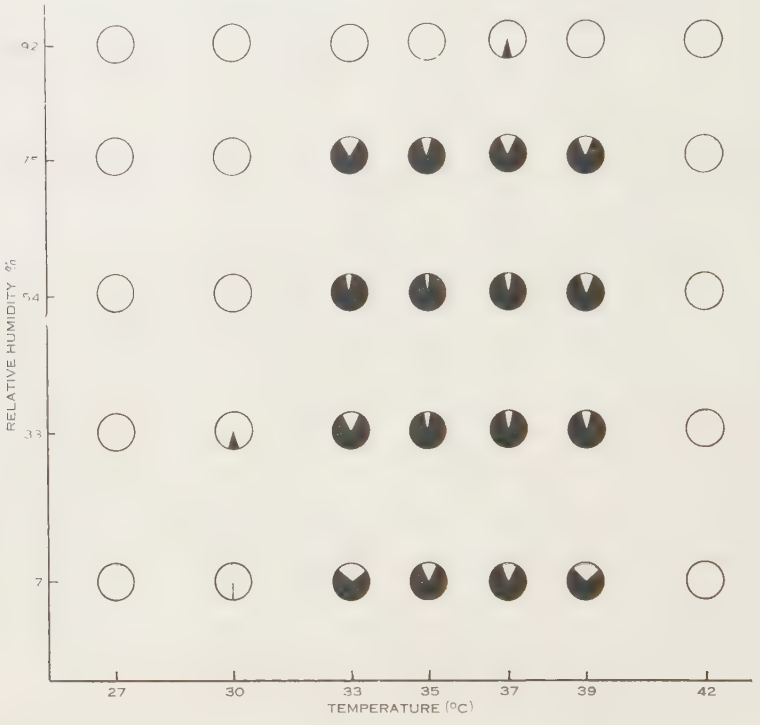

Fig. 1.—Percentage hatch of eggs of *D. ovis* maintained at constant temperatures and relative humidities. The black area within each circle represents the percentage which hatched.

Thus, under these conditions, eggs which were no more than 2 days old and those which would hatch within 24 hr could be identified.

Temperatures were maintained within ±0·5°C and humidities were controlled with saturated salt or potassium hydroxide solutions (Solomon 1951).

III. Results

(*a*) *Influence of Temperature and Humidity on the Development and Hatching of Eggs*

Wool was dry-shaved from a heavily infested sheep and the half inch nearest to the skin retained for study. Small amounts containing eggs were mounted and the position of eggs not older than 2 days noted. These eggs were then exposed to

various temperatures and humidities for 3 weeks, thus allowing sufficient time for those exposed to the lower temperatures to hatch.

It was not possible to collect sufficient eggs at any one time to expose them simultaneously to all the combinations of temperature and humidity desired. The experiment, therefore, was carried out in stages and some eggs of each collection were exposed to 37°C at 54 per cent. R.H. as a control. The remainder were divided into groups of equal number and were exposed to 27, 30, 33, 35, 37, 39, or 42°C. At each temperature a group was exposed to 7, 33, 54, 75, or 92 per cent. R.H. At least 60 eggs were exposed to each combination of temperature and humidity, after which all unhatched eggs were incubated at 37°C and 54 per cent. R.H. for another 2–3 weeks to determine whether they were still alive. All were found to be dead.

TABLE 1

INFLUENCE OF HUMIDITY ON MORPHOGENESIS OF EGGS OF D. OVIS INCUBATED AT 37°C

Collection	R.H.	No. of Eggs	No. with Fully Developed Embryo	Percentage with Fully Developed Embryo
A	54	64	54	84·4
	85	32	30	93·8
	92	35	32	91·4
B	54	26	20	77
	85	26	23	89
	92	25	15	60
C	54	176	129	73
	85	167	124	74
	92	142	98	69
Total	54	266	203	76·3
	85	225	177	78·7
	92	202	145	71·8

Eggs of *D. ovis* completed their development and hatched in the temperature range 30–39°C at R.H.'s of 7–75 per cent. but at 92 per cent. R.H. no eggs hatched except a few of those exposed to 37°C (Fig. 1).

Another collection of eggs was divided into five groups of about 40 eggs each and one group was exposed to 35°C at 54 per cent. R.H. The other four groups were exposed to less than 7 per cent. R.H. (probably *c.* 3 per cent.) by placing over calcium chloride in desiccators and one group was exposed to each of the temperatures 33, 35, 37, and 39°C. In all groups over 60 per cent. of the eggs hatched.

The eggs of *D. ovis*, therefore, were apparently unaffected by low relative humidities, but were adversely affected by high relative humidities.

(*b*) *Influence of High Relative Humidity on the Development of the Embryo within the Egg*

Female *D. ovis* were collected and exposed to 37°C at 54 per cent. R.H. in the presence of wool. After 24 hr the eggs which had been laid were removed and divided into three groups. Each group was exposed to 37°C at 54, 85, or 92 per cent. R.H. On the tenth day, just before hatching commenced, the stage of embryonic development reached within each egg was determined. In each of three experiments, the majority of the eggs contained a fully developed embryo (Table 1). Thus exposure to 92 per cent. R.H. did not prevent the complete development of the embryo.

TABLE 2

INFLUENCE OF HUMIDITY ON HATCHING OF EGGS OF D. OVIS INCUBATED AT 37°C

Collection	R.H.	No. of Eggs	No. of Eggs Hatched	Percentage of Eggs Hatched
A	54	86	84	97·7
	85	86	79	91·9
	92	84	18	21·4
B	54	26	24	92·3
	85	35	28	80
	92	55	16	29·1
C	54	58	58	100
	85	59	51	84·7
	92	60	24	40
Total	54	170	166	97·6
	85	180	158	87·7
	92	199	58	29·1

(*c*) *Influence of Humidity on Hatching*

Lice were placed on fleece wool and exposed to 37°C at 54 per cent. R.H. for 48 hr. The eggs which were laid were mounted for study and returned to 37°C at 54 per cent. R.H. On the ninth and tenth days the eggs were examined, and those which would hatch within 24 hr were divided into three groups. All groups were exposed to 37°C, one to 54 per cent. R.H., another to 85 per cent. R.H., and the third to 92 per cent. R.H. This experiment was carried out three times and similar results were obtained on each occasion (Table 2). Exposure to 92 per cent. R.H. greatly reduced the number of eggs which hatched and each of the eggs which failed to hatch contained a fully developed embryo. The adverse influence of the high humidity therefore was exerted on the hatching process.

(*d*) *Influence of Temperature on Hatching*

Eggs which would hatch within 24 hr were exposed to 54 per cent. R.H. at temperatures of 22, 25, 27, 31, 36, 39, 42·5, 44, 45·5, and 49°C and examined daily

until hatching ceased. It is shown in Table 3 that the majority of the eggs which were exposed to temperatures of 27–42·5 °C hatched. Many eggs hatched at 22°C and 25°C but the hatching of seven was delayed for as long as 5 days. Although a few hatched at temperatures of 44–49°C the majority did not, as they were killed at these high temperatures. Thus, the range of temperature within which the eggs of *D. ovis* hatch is considerably greater than that within which they develop.

TABLE 3

INFLUENCE OF TEMPERATURE ON THE HATCHING OF EGGS OF D. OVIS EXPOSED TO 54 PER CENT. R. H.

Temp. (°C)	Total No. of Eggs	No. of Eggs Hatched	Percentage Hatch	No. of Days over which Hatching Extended
22	30	13	43·3	5
25	34	25	73·5	5
27	26	21	80·8	2
31	21	18	85·7	2
36	22	20	90·9	1
39	47	39	83	1
42·5	35	33	94·3	1
44	26	3	11·5	1
45·5	32	0	0	—
49	34	2	5·9	1

IV. DISCUSSION

Morphogenesis of the embryo and hatching are two distinct physiological processes for which the temperature and humidity requirements are not necessarily the same. Eggs of *D. ovis* developed completely only at temperatures of 30–39°C but hatched from 22–42·5°C. Most completed development and hatched in the temperature range 33–39°C at 7–75 per cent. R.H. Relative humidities even lower than 7 per cent. had no apparent effect. However, maintenance at 92 per cent. R.H. was fatal to most eggs because the fully developed embryo was unable to hatch and an exposure to 85 per cent. R.H. had a slight but similar result. It would appear therefore that the lethal effect rapidly becomes important as the R.H. increases over the range 85–90 per cent. This observation was not reported by Scott (1952) who stated that eggs developed satisfactorily at R.H.'s of 50–90 per cent. There was no evidence that the eggs of *D. ovis* were capable of surviving conditions adverse to morphogenesis or hatching for long periods.

Exposure to high humidity for only the last 24 hr of development was sufficient to prevent hatching of eggs. This suggests that if such conditions persist near to the skin of the sheep for relatively short periods, hatching of many of the eggs may be prevented and thus retard an increase in the number of *D. ovis*.

For lice to reproduce on a particular region of the sheep's body, the temperature and humidity requirements for oviposition, egg development, and hatching must be

satisfied and it has now been shown that the most suitable ranges for the three processes are almost the same. When sheep with a 2-in. fleece are exposed to atmospheric temperatures of about 28°C (82·4°F), the temperature near the skin of the body rises to about 39°C (Murray 1960). This is still within the temperature range most suitable for reproduction of *D. ovis*. Under these conditions the temperatures near the skin of the legs are usually also favourable. When sheep are exposed to *c.* 6°C, however, the temperatures near the skin of the body remain suitable but those of the extremities may become too cold for considerable periods for oviposition and egg development (Murray 1960). It appears, therefore, that conditions are more consistently suitable for reproduction near the skin of the body, which may account for the characteristic distribution of *D. ovis* on sheep.

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THE BLOOD OF THE KOALA (*PHASCOLARCTOS CINEREUS*)

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Summary

Blood counts were performed on 47 specimens of *Phascolarctos cinereus*, a marsupial commonly known as the koala or native bear which lives exclusively on a diet of eucalyptus leaves, and the results were subdivided into "normal", "abnormal", and "doubtful".

Compared with man, the average normal haemoglobin was low (12·9 g/100 ml). Nucleated erythrocytes were practically always present as well as reticulocytes. Lymphocytes were more numerous than neutrophils.

In injured or infected animals, neutrophils were more numerous than lymphocytes and reticulocytes and nucleated erythrocytes were frequently absent. In blood dyscrasias, however, the latter were usually numerous. These two groups provided the abnormal results.

In the absence of definite clinical signs a considerable group of koalas exhibited deviations from the assumed normal blood picture. These deviations were usually slight and the results were referred to as doubtful.

I. Introduction

It has been stated that the koala or native bear (*Phascolarctos cinereus*), the most popular of the Australian marsupials, is prone to chills, pneumonia, kidney troubles, and infestation by intestinal parasites. It has also been claimed that millions of koalas were swept away in the years 1887–89 and 1900-03 by epidemics. An obscure form of eye disease and a periostitis of the skull were mentioned as causes of death (Troughton 1946) but no authentic report could be found and at present there is no evidence of epidemics of this or any other disease. However, the koala of New South Wales seems in danger of slow extinction because many of the animals die at a comparatively early age. This was evident to the authors during investigations on the mortality of the koala colony at Taronga Park Zoological Gardens, Sydney. Among these animals were a number of sick ones brought in from the bush, where they had been found.

Some of the first koalas examined at post-mortem seemed to have suffered from blood dyscrasias, and in order to begin an investigation on blood diseases attempts were made to establish normal values for the blood of the koala by doing a considerable number of blood counts.

II. Methods

Blood was obtained from a small incision in shaved skin near the fringe of the koala's ear. Haemoglobin was determined as oxyhaemoglobin in an ammoniacal solution and the resulting colour was read in a photoelectric colorimeter. This

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TABLE I

BLOOD COUNTS OF MALE AND FEMALE KOALAS CLASSIFIED AS "NORMAL"

Animal No.	Sex	Haemoglobin (g/100 ml)	Nucleated Erythrocytes (per 100 leucocytes)	Erythrocytes per cu. mm ($\times 10^6$)	Reticulocytes (per 100 erythrocytes)	Leucocytes per cu. mm ($\times 10^3$)	Neutrophils (%)	Eosinophils (%)	Basophils (%)	Lymphocytes (%)	Monocytes (%)	Remarks
3	♀	12·0	3·6	1		4·7	33	1	0	64	2	First count
3	♀	12·0	3·4			4·0						
3	♀	14·3		4	1·2	6·2	21	0	0	75	4	Following day
5	♂	11·7	3·2			4·4	24	8	0	67	1	After 6 months
6	♂	11·3	3·8	1		4·0	36	1	0	58	5	
9	♀	11·6	3·4			7·3	40	3	0	52	5	
12	♂	11·9	3·0	0·5		6·2	45	1	0	52	2	After penicillin
14	♀	12·4	3·5	3		5·6	34	1	0	61	4	
15	♂	12·0	3·5	4		4·1	10	1	0	83	6	
18	♂	12·3		1	0½	5·6	17	0	0	81	1	
19	♂	13·1		0·05	0·1	8·5	25	3	1	69	2	
20	♂	13·6		1	0	8·7	24	5	0	68	3	
24	♂	15·2		1	0·8	7·0	34	3	1	57	5	
25	♂			5			35	1	0	62	2	
26	♂	12·6		5	0·2	6·4	12	3	1	82	2	
29	♀	13·5	3·4	4	0	8·2	26	4	0	68	2	After penicillin
30	♂	12·2	3·5	1	0·2	8·3	23	4	0	72	1	First count
30	♂	12·7	3·5	0·5	0·4	5·6	37	1	0	60	2	After 1 month
34	♀	14·3	3·8	4	1·2	6·2	21	0	0	75	4	
35	♀	14·7		1	1·2	3·6	42	6	0	49	3	
36	♂	14·7	5·0	0·5	0·8	3·7	25	1	0	69	5	
37	♀	11·7	3·3	3	0·4	6·6	20	2	0	74	4	First count
37	♀	12·6		2	0·2	7·4	10	0	0	83	7	After 1 week
37	♀	11·9		0·5	0	5·3	11	1	0	86	2	After 2 weeks
38	♂	15·6		1	0·4	10·5	24	1	0	74	1	
39	♀	13·7			1·2	8·2						
40	♂	12·6				5·0						
44	♂	11·3	3·4			6·6	25	0	1	70	4	
47	♂	13·7					8	0	0	89	3	
Mean		12·90	3·53	2·00	0·50	6·22	25·46	1·96	0·12	69·23	3·15	
S.D.		1·23	0·45	1·64	0·46	1·78	10·45	2·07	0·33	10·94	1·67	
S.E.M.		0·23	0·12	0·35	0·11	0·34	2·05	0·41	0·06	2·15	0·33	

instrument was frequently checked by means of a standard solution of oxyhaemoglobin. Red and white cell content was determined by standard methods and blood smears were stained with Leishman's stain. Reticulocytes were stained supravitally with brilliant cresyl blue by the following method: a drop of an alcoholic solution of the dye (0·3 per cent.) was spread on a slide and left to dry. A drop of blood was transferred to the slide and mixed with the dye and then spread in a thin film. The film was allowed to dry and was counterstained with Leishman's stain. The percentage of reticulocytes present was established after counting 500 erythrocytes.

Nucleated erythrocytes were counted simultaneously with the differential leucocyte count of the stained smear. They were recorded as nucleated erythrocytes per 100 leucocytes.

III. Results

(*a*) *General Remarks*

Blood counts were performed on 47 koalas, mostly fully grown, of varying age and sex. Counts from apparently healthy specimens fulfilling certain criteria to be discussed later were considered "normal" (Table 1).

The results of a number of determinations on diseased animals were considered "abnormal". The abnormals were further subdivided into two subgroups:

(1) Consisting of animals with some obvious infection or injury;

(2) Those with grossly abnormal blood findings provisionally referred to as blood dyscrasias (Table 2).

"Doubtful" results were obtained from apparently healthy koalas showing some deviations from the normal blood picture (Table 3).

The counts done on some of the koalas were later repeated (Tables 1, 2, and 3), sometimes following the administration of penicillin to infected or injured specimens. The resulting improvements in the latter cases were such that the values for certain koalas in Table 2 were transferred to Tables 1 or 3. No blood parasites were encountered in any of the animals examined.

(*b*) *Haemoglobin*

A total of 54 haemoglobin determinations were performed on 44 koalas. The average values were about the same for the three groups. The normal values, however, were fairly close together when compared with the broad range of abnormal values which included the typically anaemic as well as possibly polycythemic animals.

(*c*) *Erythrocytes*

These are of the general mammalian pattern and are about the size of a human erythrocyte. Measured by the photographic method they had an average diameter of 8 μ. Nucleated erythrocytes, mainly in the form of normoblasts, were always found in smears of normal koalas, but sometimes more than 100 leucocytes had to be counted to encounter a nucleated erythrocyte, and on five occasions out of 22 counts only one was found amongst 200 leucocytes. Otherwise, as many as five normoblasts were present in a count of 100 leucocytes.

TABLE 2

BLOOD COUNTS OF MALE AND FEMALE KOALAS CLASSIFIED AS "ABNORMAL"

Results for animals with symptoms of blood dyscrasias given in second half of table

Animal No.	Sex	Haemoglobin (g/100 ml)	Erythrocytes per cu. mm ($\times 10^6$)	Nucleated Erythrocytes (per 100 leucocytes)	Reticulocytes (per 100 erythrocytes)	Leucocytes per cu. mm ($\times 10^3$)	Neutrophils (%)	Eosinophils (%)	Basophils (%)	Lymphocytes (%)	Monocytes (%)	Remarks
4	♂	15·0	5·6	0	0	21·0	74	0	0	14	12	Pulmonary infection, fatal
11	♂	13·9	4·0	0	0	14·0	56	1	0	39	4	Respiratory infection
12	♀	12·4	3·4	0	0	25·5	74	1	0	15	10	Respiratory infection
12	♀	11·0	3·5	0	0	12·1	54	1	1	37	7	Recovered after penicillin (see Table 1)
28	♀	11·6		0	0	48·6	70	1	0	21	8	Severe injury, penicillin given
28	♀	14·7		0	0	7·1	59	0	0	39	6	One week later, penicillin repeated
28	♀	12·8		0	0	10·6	55	0	0	38	7	Two weeks later, penicillin repeated, died third week
29	♀	11·9		1	0	11·3	68	2	0	24	6	Anorexia, recovered after penicillin (see Table 1)
32	♂	12·8		0	0	19·4	38	1	0	52	9	Skin sores
42	♂	17·2		0	0	7·7	74	0	0	19	7	Died following day
45	♂	15·0	4·9	4	0	8·2	63	0	0	34	3	Anorexia, died 2 weeks later
46	♀	11·8	2·9	0·5	0	15·3	77	0	0	15	8	Internal and external injuries, died following day
						Blood Dyscrasias						
7	♂	6·5	2·3	20		4·9	1	0	0	99		Died after 7 months
10	♀	10·5	2·9	24	0·6	4·8	39	3	0	53	5	Died after 2 months
17	♀	7·4	1·9	8	0·4	5·2	43	0	0	48	9	Died after 3 months
23	♀	9·1		10	0	14·6	61	0	0	33	6	Died following day

In the infected or traumatic (abnormal) group, nucleated erythrocytes were practically absent. On the other hand, large numbers of normoblasts were seen in the animals with low haemoglobin content (Table 2).

In 17 normal blood counts the reticulocytes were also counted. These supravitally stained cells were found in most instances and on four occasions more than 1 per cent. of the erythrocytes showed reticulocytosis. In the infective or traumatic group reticulocytes were never observed.

In 15 normal koalas the erythrocytes were counted. They ranged from 3 to 5 million cells per cu. mm and the mean corpuscular haemoglobin ranged from 29 to 40 $\mu\mu$g, mean 35 $\mu\mu$g.

(*d*) *Leucocytes*

The normal leucocyte count as determined on 27 blood smears from 23 koalas ranged from 3600 to 10,500 cells per cu. mm of blood, with an average of 6200 (Table 1). In the abnormal group (Table 2), the leucocytes were increased in number and reached values of nearly 50,000 cells per cu. mm.

The normal differential count revealed a relative lymphocytosis as frequently seen in mammals. The average percentage of neutrophils was 25 and that of the lymphocytes 69. The latter always outnumbered the neutrophils. Eosinophils were frequently seen and varied from 0 to 8 per cent., average 2 per cent. Basophils were only observed in four counts and numbered 1 per cent., whereas monocytes were present in every count numbering up to 5 per cent. in several bears.

In koalas classified as infected or injured both the total and the differential leucocyte counts were altered. The neutrophil/lymphocyte ratio was always reversed compared with normal koalas, i.e. more neutrophils than lymphocytes were present.

(*e*) *Normal, Abnormal, and Doubtful Blood Pictures*

As shown in Table 2 the blood picture of the infected and injured koalas shows four types of deviation from the normal:

(1) An increased number of leucocytes. Values below 10,000 leucocytes per cu. mm, however, were repeatedly observed in moribund animals.

(2) Reversal of the neutrophil/lymphocyte ratio. Compared with normal bears more neutrophils than lymphocytes were present.

(3) Increase in the number of monocytes. In 11 out of 13 counts the monocytes exceeded the upper normal limit and as many as 12 of these cells were present per 100 leucocytes.

(4) Absence of nucleated erythrocytes and reticulocytes.

In seven out of 12 counts, all four types of deviation were found while four counts had three and one count two of these deviations.

Penicillin (1 million units) was administered to some of the koalas with abnormal counts, and two thus treated recovered and the blood picture became normal, as listed in Table 1.

Four koalas whose haemoglobin values were below normal and who had 8 per cent. or more of nucleated erythrocytes in a differential count are listed under the

TABLE 3

BLOOD COUNTS OF MALE AND FEMALE KOALAS CLASSIFIED AS "DOUBTFUL"

Animal No.	Sex	Haemoglobin (g/100 ml)	Erythrocytes per cu. mm ($\times 10^6$)	Nucleated Erythrocytes (per 100 leucocytes)	Reticulocytes (per 100 erythrocytes)	Leucocytes per cu. mm ($\times 10^3$)	Neutrophils (%)	Eosinophils (%)	Basophils (%)	Lymphocytes (%)	Monocytes (%)
8	♂	14·8	4·5			11·0	22	4	0	67	7
16	♀	13·7	4·2	0	0	13·0	40	0	0	60	0
21	♂	11·5		0	0	12·9	42	7	1	45	5
22	♂	12·2		0	0	12·3	33	1	0	54	12
25	♂	17·6		8	0·9	6·4	24	1	1	72	2
27	♀	10·6		1		3·7	53	1	0	44	2
27	♀	10·0		3	0·6	3·3	65	0	0	33	2
27	♀	12·5		6	1·6	6·3	78	0	0	20	2
33	♀	12·5		0·5	1·8	12·7	28	2	0	60	10

subgroup of blood dyscrasias (Table 2). Attempts were made to treat these animals but the administration of iron, liver extract, folic acid, and vitamin B_{12} singly or in conjunction produced no clinical improvement and the animals ultimately died. The history of these koalas and the results of numerous blood counts will be given on another occasion.

The third group, referred to as doubtful, consisted of apparently normal koalas whose counts disagreed to a minor extent with the normal counts. Thus, five out of the eight koalas showed moderate leucocytosis, three others had reversion of the neutrophil/lymphocyte ratio, and another had 8 per cent. of nucleated erythrocytes and an excessively high haemoglobin content. Nos. 8 and 33 also had a degree of mononucleosis (Table 3).

IV. Discussion

Recently the blood of the echidna, *Tachyglossus aculeatus* (one of the two surviving species of the allegedly lowest order of the mammalian class), has been examined (Bolliger and Backhouse 1960). By comparison the normal blood picture of the koala was more complex. In koala blood, nucleated erythrocytes and reticulocytes were always present and eosinophils and monocytes occurred in greater numbers than in the echidna. Compared with man these characteristics would appear to be abnormal. By the same token haemoglobin values of koala's blood were low compared with either man or echidna, possibly indicating a tendency to anaemia. It is noteworthy that nearly 10 per cent. of the koala's examined had an anaemia. This may be related to their remarkable diet of eucalyptus leaves which are poor in protein and rich in phenolic substances toxic to other mammals. This dietary problem in itself makes this investigation a significant one. Blood counts of other marsupials on other diets have been reported (Ponder, Yeager, and Charipper 1928; Wintrobe 1956) but these counts were sometimes not complete and were frequently done on only one animal whose general health was not stated.

The subdivision of our results into normal and abnormal is an arbitrary one but seems to fit the values reasonably well. The "doubtful" subdivision is a less convincing one and probably some of these results belong with the normal ones.

In a few koalas it was possible to repeat the blood count one or more times. These results agreed satisfactorily in each animal (Tables 1 and 3). This and the consistency of the normal values in a significantly large group of animals supports the assumption that these counts have some meaning and one cannot help suspecting that some of the "doubtful" values are not merely physiological variations but are the expression of some morbidity. Undoubtedly a larger series of koalas would have to be observed over long periods of time to delineate more sharply, if possible, between normal and abnormal blood pictures.

At present, it seems difficult to evaluate these findings in terms of comparative haematology and they are published now mainly to record them.

Penicillin was given to some of the koalas classified as infected. Two of the treated animals recovered and their subsequent blood counts were normal. Thus it was felt that unapparent and ultimately fatal infections could be detected by simple blood studies and the animals saved by the administration of antibiotics.

We were unsuccessful in endeavouring to cure blood dyscrasias. However, these diseases may provide an experimental approach to the study of unusual blood disorders.

V. Acknowledgments

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BREEDING THE SHORT-NOSED MARSUPIAL BANDICOOT, *ISOODON MACROURUS* (GOULD), IN CAPTIVITY

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Summary

The short-nosed bandicoot is polyoestrous, breeding all the year round in the vicinity of Brisbane. Females may breed when only half grown. In captivity, one female has produced eight litters in 17 months, totalling at least 32 young, most of which she destroyed early in their life. The gestation period is less than 15 days. Up to seven young may be born at one time. There are eight teats in the pouch. The length of the oestrous cycle was not determined.

The young are born in the embryonic stage usual in marsupials. They are naked and blind, with the lips fused at the sides. They have relatively well-developed nostrils and fore limbs, and are able to make, unaided, the journey from the median vaginal canal to the exterior, and thence to the pouch.

They weigh about 0·18 g, and measure about 14 mm from crown to rump. Deciduous claws, shed during the first week of life, are present on the second, third, and fourth digits of the manus. The young remain attached to the teats for about 7 weeks, when they are fully haired, the lips have separated, teeth erupted, and the eyes opened. They continue to suckle for about 10 days longer.

The maximum weights recorded for adult animals are 2045 g for a female and 2870 g for a male.

I. Introduction

Although many species of marsupials breed readily in captivity, there are no records of the establishment of a breeding colony of bandicoots. Wood-Jones (1924) reared two young South Australian barred bandicoots, *Perameles myosura* Wagner, which subsequently mated and produced young. However, he stated that the female "always evinced a strong tendency to kill and eat her progeny, even when they were grown to half their adult size". After many unsuccessful attempts, we obtained a pair of short-nosed bandicoots which bred fairly regularly for about 18 months. Unfortunately, the female proved to be even more cannibalistic than Wood-Jones' specimen of *P. myosura*, as she has destroyed most of her progeny before they reached the stage of independence. Consequently, the data recorded here are not as complete as we would have wished.

The nomenclature of this bandicoot has been discussed by Mackerras and Mackerras (1960). It is the only short-nosed species that we have encountered in our studies of small mammals as reservoirs of infection in northern Queensland between Innisfail and Mossman and in southern Queensland between Gympie and Tamborine, and is undoubtedly conspecific with *Isoodon macrourus* (Gould), which was described

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from the Northern Territory. The species studied by Hill (1897) may, however, have been the true *I. obesulus* (Shaw), which has a southern distribution.

II. General Observations

Bandicoots in captivity behave as solitary, pugnacious animals. We have found it impracticable to keep more than one pair in an enclosure together. Even then, it is essential to choose animals of approximately equal size; otherwise the smaller will be maimed or killed. Administration of a tranquillizer, as described below, appears to be useful in calming the animals prior to mating.

The females reared in captivity have not so far produced any young,* and the males have proved more aggressive and unmanageable than captured adults. The food is probably deficient in some necessary factor. It is certainly too soft, as the molar teeth of many become heavily coated with tartar, the gums become infected, and all teeth gradually loosen. When this happens, the animal loses weight, and eventually dies. The substitution of a natural diet of insects and earthworms would be desirable.

Both captured and reared bandicoots behave as strictly nocturnal animals in the outdoor enclosures, remaining hidden by day in shallow burrows covered with straw. Within the laboratory, however, they will move about and feed by day, if taken out of their cages and placed on the floor for exercise.

The following weights have been recorded for captured females carrying pouch young in the Brisbane district: 670, 730, 880, 930, 1000, 1060, 1380, and 1400 g. Our breeding female weighed 1620 g and has increased to 2045 g, the heaviest weight recorded for a female. Dr. J. L. Harrison, at the Institute's Field Station, Innisfail, has informed us that the weights of 17 captured females carrying pouch young ranged from 563 to 1130 g. Males usually grow larger than females, frequently reaching 2000 g, the maximum weight recorded being 2870 g.

It is clear that bandicoots may breed in their first year. The lightest mothers caught only weighed as much as some laboratory-reared females did at about 6 months. One female of known age weighed 590 g at 21 weeks, and 720 g at 26 weeks.

Pouch young have been found in every month of the year. Up to seven small naked young have been found, but the number usually decreases as the size of the babies increases. As a rule, only two or three hairy young have been found, but on one occasion five were present.

We have little information about the duration of maternal care in the natural state. Mother bandicoots have never been seen to protect their young when brought into the laboratory; on the contrary, their usual reaction is to kill and eat them. The five hairy young mentioned above were all killed. Dr. Harrison has found that the largest young trapped with its mother at Innisfail weighed 108 g and that the smallest animal trapped alone weighed 107 g. Our values for weights at weaning varied considerably. Two animals removed during the seventh week, when they weighed 64 and 112 g, had to be fed forcibly. Those weaned naturally during the eighth week weighed from 138 to 212·5 g.

* See Addendum, p. 382.

III. History of the Breeding Pair

The adults were trapped in different suburbs of Brisbane on September 12, 1958. The female was carrying two large babies in the pouch. She was kept in a cage by herself, and handled very little. Two weeks later, the babies were fully haired, and beginning to leave the pouch. They weighed 99 and 100 g. A few days later, both were found to be completely hairless, and, as the mother was beginning to bite them, they were removed and reared separately.

On the same day, September 29, the male and female were each given about half of a 0·25-mg tablet of reserpine in milk. They were placed together in a covered enclosure measuring 13 ft by 4 ft 4 in., with a concrete floor covered with a thick layer of sawdust. Straw and wooden boxes were provided for nesting. Food consisted of raw minced steak, "Farex", bran, egg, and milk, to which was added salt and cod-liver oil. Reserpine (0.25 mg) and vitamin E (10 mg) were sprinkled on the food daily. The pouch of the female was inspected daily, except at the weekends. On October 28, six young were found attached to teats. Three had disappeared on November 5, but three large babies were still present on December 2 (35th day). However, only two were found on December 3, and they had both disappeared by December 4. The male had been removed soon after the birth of the young, the mother was handled very gently and only by one person, and there was no apparent reason why all the babies should have been destroyed.

On January 19, 1959, she was placed with the same male, and tranquillizer and vitamin E given as before. One baby was found attached to a teat on February 4, and a second was present next day, probably born on the previous day after the morning inspection. Litter 2 was photographed *in situ* at intervals (Plate 1, Figs. 1–6). One baby was found dead and partly eaten on March 19 (43rd day). The other continued to thrive, but on March 25 it was found to be bitten about the face, and was removed and reared artificially. The male had been removed shortly after the birth of the young, and the pair was not mated again until early in May.

On May 25, in an attempt to provide more natural conditions, they were transferred to a new enclosure 14 ft 4 in. by 5 ft 5 in., which had an earth floor and was exposed to morning sunlight. On June 18 and 19, the pouch was noticed to be very moist and pink, and on June 20 four babies were found attached to teats. The fur all about the opening of the pouch and on the inside of the thighs was quite wet. On July 13, only three young were present, and on August 3 only two. On August 4 (45th day), both babies were found lying on the ground, cold and dirty, in the hollow usually occupied by the mother. They were removed, and one was reared successfully.

The male had not been removed on this occasion, and on August 17, i.e. 13 days after lactation ceased, seven young were found in the pouch, some not yet attached. Two were removed for preservation. The remainder of this litter had disappeared by the end of the first week. The male was not removed.

On September 22, 23, and 24, we noted the same sequence of events as had been observed in June. One baby was seen to have reached the pouch on September

24, but it disappeared shortly afterwards. Next morning, the pouch was empty and only slightly moist and pink.

After the usual premonitory signs, three babies were found attached to teats on October 30. From the amount of milk in the gut visible through the skin, it is likely that they had been born the previous day. One was removed and photographed alive (Plate 2, Fig. 2). The others grew well at first, but one was missing on November 9, and the other had disappeared next day.

On December 4 and 5, the pouch was again moist, and the fur around the margin was wet. It was not examined on December 6, but on the next day five babies were present. Two of them disappeared between December 12 and 14, but the remaining three developed normally. On January 19, the male was removed from the enclosure, and a deep layer of straw was added to give the young means of concealment when they left the pouch. At the end of 7 weeks (January 25), the babies were fully haired, their eyes were open, and they were begining to leave the pouch. On the 60th day (February 5), only one was found with the mother, and it seems likely that lactation had practically ceased, the three large teats being noticeably smaller than they had been a week earlier.

This was the first time that the female had not attacked her young. One addition made to her diet, the provision of as much milk as she would drink daily, may have contributed to the successful result. The provision of a deep layer of straw and two large, heavy boxes, under which the adults burrowed, may also have contributed in providing good places for concealment.

The female was mated again on February 8, and on February 23 four babies were present. The three teats in use during the previous lactation had not returned to normal size when this litter was born. One baby disappeared, but three developed normally up to the end of the third week, when one was taken for weighing and measuring. The others were weaned on the 56th day.

Details of the eight litters born in captivity are summarized in Table 1.

IV. Gestation Period

Some indication of the length of the gestation period may be obtained from litters 2, 4, and 8. In litter 2, the period was certainly less than 16 days, and in litter 8 less than 15 days. In litter 4, it may have been less than 13 days, but the male had been present throughout, and fertilization may have occurred before the previous litter was removed.

V. Parturition and Attachment

The actual process of parturition was not observed, but we noticed that the female became very irritable before the event, resenting handling, and struggling more than she usually did: also that the pouch became moist and pink for about 2–3 days prior to parturition. On the day of parturition, the fur around the pouch and on the inside of the thighs became quite wet. We did not observe the female licking the area, but Dr. Harrison observed a female giving birth to young in a trap at 11 a.m. There was one baby just inside the pouch and another just emerging from the cloaca.

The fur between the orifice and the pouch was quite wet, and the mother was seen to lick the upper part of the area. She was lying on her side with one hind leg held up in the air.

At the time when the young reaches the pouch, the teats are very small, firm, and pointed, and the infant apparently draws the tip of one into its tiny mouth by suction with its well-developed tongue. It holds the teat firmly in its mouth during its pouch life. The teat enlarges and elongates considerably during this period. At no stage is there any union between the teat and the baby, which can always be removed without damage by gentle traction. The term attachment is used merely to indicate the firm and continuous grasp exerted by the baby.

TABLE 1

LITTERS BORN IN CAPTIVITY

Litter No.	Date Lactation Ceased	Date ♀ Placed with ♂	Date Young Born	No. of Young Observed	No. Survived
1	29.ix.58	29.ix.58	28.x.58	6	0
2	4.xii.58	19.i.59	4.ii.59	2	1
3	25.iii.59	1.v.59	20.vi.59	4	1
4	4.viii.59	1.v.59	17.viii.59	7*	0
5	24.viii.59	1.v.59	24.ix.59	1	0
6	24.ix.59	1.v.59	30.x.59	3†	0
7	10.xi.59	1.v.59	7.xii.59	5	3
8	5.ii.60	8.ii.60	23.ii.60	4†	2

* Two removed for preservation. † One removed for preservation.

An observation made by Mr. D. Fleay, West Burleigh, Qld., shows that the new-born young can leave the maternal passages and reach the pouch unaided. An injured female bandicoot was brought to Mr. Fleay one evening in the last week of August, 1959. There was nothing in the pouch. As the animal was badly injured, it was destroyed by a blow on the head, but was left lying on its side on a bench overnight. In the morning, three embryos were found in the pouch; they had failed to become attached, and died.

VI. Development of the Pouch Young

The lining of the pouch is moist and glistening, and the young squirm about actively when the pouch is inspected. The hind limbs are well defined at the end of the first week. The eyes become clearly indicated by dark rings contrasting with the pink body colour. The head gradually assumes the adult shape, and ceases to be firmly flexed at right angles to the trunk. By the end of the third week, the shape and proportions resemble those of the adult. The ear lobes become distinct, and vibrissae appear. During the fifth week, the skin begins to darken, due to the rapid growth of the hair follicles. At the end of the sixth week, the skin is quite dark, and two

types of hairs are showing—strong dark hairs and pale fine ones. The facial vibrissae are now well developed.

During the seventh week, the body becomes completely covered with hair, teeth appear, the eyes open, and the lips separate. The little bandicoot is now a replica of the adult. It leaves the pouch voluntarily at the end of the seventh week, but is at first unsteady on its feet. It continues to suckle, and under natural conditions is dependent on the mother for 1–2 weeks longer.

Some information gleaned from captured animals is included in the more detailed descriptions that follow, the age being estimated by comparison with young of known age.

TABLE 2

MEASUREMENTS OF YOUNG BANDICOOTS

No. of Specimen	Age (days)	Sex	Weight (g)	Length (mm)		Head (mm)	Tail (mm)	Hind Foot (mm)
				Crown–Rump	Nose to Butt of Tail			
1	Newborn		0·18	13·5		4·5	4	
2	Few hours		0·22	14·5		5	3·5	
3	Few hours		0·24	13·5		5	3·5	
4	7–14		1·15	29		10	5	3·5
5	7–14		1·21	29		10	5	3·5
6	21	♂	8·3		72	23	17	13
7	21–28	♀	10·2		75	25	24	16
8	21–28	♀	9·5		72	25	22·5	15
9	?35	♂	33·5		114	39	42	26
10	?35	♀	32·3		112	39	44	26
11	45	♀	64					
12	49	♀	68		135	43	55	32
13	49	♂	112					
14	?52	♂	192·5					
15	?52	♂	212·5					
16	53	♀	138					
17	53	♀	140					
18	53	♂	145					
19	56	♀	190		208	55	70	41
20	56	♀	195					

(*a*) *New-born Young*

One unattached baby weighed 0·18 g, and one removed from the teat, and which had probably taken a little milk, weighed 0·22 g (Nos. 1 and 2 in Table 2). After preservation in 70 per cent. alcohol, they weighed 0·154 and 0·196 g respectively. They measured 13·5 and 14·5 mm in crown–rump length, as measured between parallels. The unattached young obtained by Mr. Fleay from the dead mother weighed 0·148, 0·170, and 0·172 g, and measured from 13 to 14 mm in crown–rump length after preservation in spirit. The baby removed from the teat on October 30, when

it was less than 24 hr old, weighed 0·241 g, and measured 13·5 mm in crown–rump length in the living state (No. 3 in Table 2).

The body is covered with clear, smooth epitrichium, through which a network of cutaneous blood vessels is clearly seen (Plate 2, Fig. 2). The head is relatively large, and bent almost at a right angle with the trunk. The lips are fused, and the mouth D-shaped; the tongue is large, and protrudes slightly. The eyes are indicated by faint dark rings, and the ears by tiny pale spots. The nostrils are well developed, raised, circular in outline, and facing laterally (Plate 2, Fig. 1). The fore limbs are relatively well developed, and the digits clearly defined. Needle-like, clear, deciduous claws about 0·3 mm long are present on the second, third, and fourth digits. On the live animal, they may be seen under the dissecting microscope to become firmly flexed with each down stroke of the fore limb. The hind limbs are rudimentary, and the digits only faintly indicated. The tail is short, and curled between the hind limbs. The stump of the umbilical cord is visible. The red cells are nucleated. The sex cannot be determined. The appearance is in every way similar to that of the new-born *Perameles nasuta* Geoffroy described and figured by Hill (1897).

(*b*) *Second Week*

Two pouch young (Nos. 4 and 5 in Table 2) which were estimated to be between 1 and 2 weeks old, weighed 1·15 and 1·21 g, and measured 29 mm in crown–rump length; the head was 10 mm, the tail 5 mm, and the hind foot 3·5 mm. The lobe of the ear was not raised, the nostril was circular, and the mouth was a pin-hole. Claws of the adult type were present on the second to the fourth digits of the fore limb. A minute claw was present on the fourth digit of the hind foot.

These two babies showed great tenacity to life. They survived the death of the mother for many hours, about six of which were spent in a refrigerator. When exposed to room temperature, they soon became quite active again.

(*c*) *Third Week*

One baby was removed from litter 8 when 21 days old (No. 6 in Table 2). In the living state it weighed 8·4 g, and measured 72 mm from nose to butt of tail; the head was 23 mm, the tail 17 mm, and the hind foot 13 mm. The ear lobe was raised, and the tragus just discernible. The line of division between the upper and lower eyelids was visible. The nostril was curved. The scrotum was distinct. There were well-developed claws on the second to the fourth digits of the fore limb, and on the second to the fifth on the hind limb. The skin was bare except for the vibrissae, which were beginning to appear. There were eight fairly long, black mystacials and a few pale, short ones, two black supra-orbitals, and three colourless genals on the face. There were numerous, fine, short, pale, submental bristles on the chin, and a few pale inter-ramal bristles. A long, pale, antebrachial bristle was present on each forearm.

(*d*) *Fourth Week*

Two pouch young (Nos. 7 and 8 in Table 2) which were estimated to be a little over three weeks old weighed 10·2 and 9·5 g; the lengths from nose to the butt of

the tail were 75 and 72 mm, the head 25 mm in both, the tail 24 and 22·5 mm, and the hind foot 16 and 15 mm. There were a few long, black, mystacial vibrissae, and numerous short, black ones, becoming paler towards the margin of the lip. The ear lobes were raised, the nostrils curved, and the mouth slit-like. Both were females, the pouch being distinct, and the nipple area clearly indicated.

(*e*) *Fifth Week*

On October 20, 1959, a female was trapped with four large, naked, pouch young. Three of the babies had fallen out of the pouch. Efforts were made to return them to the pouch, and one succeeded in regaining a teat. Two, which failed to re-attach, were a male and female, weighing 33·5 and 32·3 g respectively (Nos. 9 and 10 in Table 2); their lengths from nose to butt of tail were 114 and 112 mm, the head 39 mm in both, the tail 42 and 44 mm, and the hind foot 26 mm in both. The skin had darkened slightly, and the tips of strong, dark hairs were showing on all parts of the body. The external ear was completely formed, but the canal appeared to be closed. The lips were separated on each side from the angle forward for 5–8 mm. The scrotum and pouch were well developed. The estimated age was about 5 weeks.

(*f*) *Seventh Week*

The siblings of the pair just described were still in the pouch, fully haired, but with eyes closed on November 2. Next day one was out of the pouch, with eyes, opened. On November 6, both were found out of the pouch. They weighed 192·5 and 212·5 g (Nos. 14 and 15 in Table 2). Both were males. They evidently continued to suckle from outside until about November 11, two teats elongating sufficiently to protrude through the opening. On November 13, the teats were smaller, and had withdrawn into the pouch, and it is probable that lactation ceased about this time, as the teats became progressively smaller each day. The babies weighed 230 and 245 g on November 13. They were exceptionally large when they left the pouch, and it was thought that they had gained a double supply of milk, when their siblings were lost on October 20. Their rapid growth during the weaning period is in contrast to the failure of the artificially reared babies to thrive at this stage.

From litter 2 we obtained a male, which weighed 112 g on the 49th day (No. 13 in Table 2), and from litter 3 we obtained two females each weighing 64 g on the 45th day. They seemed unusually small. One of them (No. 12 in Table 2) died on the 49th day, but the other (No. 11 in Table 2) survived. These little animals were difficult to feed. They kept their teeth tightly clenched, resented the introduction of a rubber-tipped pipette, and only took very small quantities of milk at a time. The lips of the female were not completely separated on the 48th day (Plate 2, Figs. 3 and 4). After a few days, however, they learned to eat squeezed-out meal worms (*Tenebrio molitor*), and after about a week they could eat minced meat and "Farex" mixed with milk. Naturally, they failed to thrive during the weaning period but once they were able to eat solid food they began to gain weight.

When litter 7 reached the critical weaning period, it was disturbed very little. On the 53rd day, two females and one male weighed 138, 140, and 145 g respectively

(Nos. 16–18 in Table 2). One week later their weights had increased to 190, 190, and 195 g. Litter 8 was treated in the same way. The two babies were still in the pouch on the 55th day, but were found away from the mother next day, when they weighed 190 and 195 g (Nos. 19 and 20 in Table 2). The weights and measurements of pouch young are set out in Table 2.

After weaning, the most rapid gain in weight took place between the 9th and 16th weeks, the male from litter 2 gaining about 10 g daily, and the female from litter 3 about 4 or 5 g daily. After the sixth month, growth slowed down, and in some weeks the weight remained stationary. At 6 months, the male weighed between 900 and 1000 g and the female 720 g. At one year, the male weighed 1480 g and the female 1120 g. The growth of these animals during their first year is set out in Figure 1.

Fig. 1.—Growth curves of male and female bandicoots during their first year.

On several occasions, we have observed pouch young lose their first coat entirely during the eighth week, sometimes becoming quite bald. The next hairy coat was at first soft and uniformly grey, and only gradually assumed its original grizzled appearance.

VII. Discussion

The most extensive studies on the reproduction of an Australian polyprotodont marsupial are those of Professor J. P. Hill and his colleagues, begun in Sydney in the last decade of the 19th century, although some of the work has only been published recently (Hill and Hill 1955). They studied the native cat, *Dasyurus quoll* (Zimmermann), which they considered to be monoestrous, with the breeding season restricted to the winter months, May to August. The gestation period was said to be not less than 8 and not more than 14 days (Hill and O'Donoghue 1913). They found that many more embryos developed than could possibly be reared, and even many more new-born young reached the pouch than could be accommodated on the six teats, 10 and 18 being the largest numbers observed. The new-born young measured 7 mm in length, and weighed about 12·5 mg. Deciduous claws were present on the second to the fifth digits of the manus. The nursing period was divided into two phases, a period of fixation lasting 7 or 8 weeks, and a free period lasting a further 8 or 9 weeks.

Hill (1897) also studied the intra-uterine stages of bandicoots, *Perameles nasuta* and *Isoodon obesulus*, and made observations on the new-born young of the former. Lyne (1951, 1952, 1957) has studied the pouch young of several bandicoots, particularly with regard to the development of the hair follicles and he discussed the development of *P. nasuta* from birth onwards in a paper read to Section D, Australian and New Zealand Association for the Advancement of Science, at Adelaide in August, 1958.

The American opossum, *Didelphis virginiana* Kerr, is polyoestrous, the breeding season extending from January to October, two litters usually being reared each year. Numerous ova are shed, and about 10 young are usually born at a time. The gestation period is 12·5 days (Asdell 1946). Reynolds (1952) studied the same species in great detail, and observed intervals of 12 days 20½ hr and 13 days 4½ hr between copulation and parturition. The young did not begin to leave the pouch until the 11th week after birth, and continued to suckle until the 15th week.

TABLE 3

COMPARATIVE DEVELOPMENT OF SOME AUSTRALIAN MARSUPIALS

	Isoodon	*Dasyurus*	*Trichosurus*	*Setonix*
Completely furred	*c.* 45–49 days	Little over 60 days	*c.* 100 days	*c.* 130 days
Eyes open	*c.* 45–49 days	*c.* 75 days	87–122 days	*c.* 105 days
Leave pouch	*c.* 8 weeks	*c.* 3 months	3½–4 months	5–5½ months

Some diprotodont marsupials have also been investigated. Sharman (1955*a*, 1955*b*) showed that the quokka, *Setonix brachyurus* (Quoy & Gaimard), is polyoestrous, the cycle lasting about 28 days. In the wild state, an anoestrous phase occurs during the spring and early summer. A single egg is shed, and the young are born after a gestation period of 27 days. Lactation may last 8 or 9 months. Lyne, Pilton, and Sharman (1959) have shown that the possum, *Trichosurus vulpecula* (Kerr), is polyoestrous, with a cycle of 21–30 days. The gestation period is about 17·5 days. In the Sydney district, usually only one young is reared in the wild state annually, but near Adelaide they may rear two babies in a year. Lyne and Verhagen (1957) studied the growth of this species, and compared it with that of some higher mammals.

Bandicoots have anatomical features which link them with both major groups of marsupials. Their dentition is typically polyprotodont, but they possess syndactylous digits on the hind foot, like the diprotodonts. In their reproductive physiology, they also resemble both groups in some respects, and differ in others. Reproductively, they appear to have most in common with the American opossum, both being polyoestrous, with a long breeding season and a capacity for producing numerous young at a time. The rate of development of *I. macrourus* is, however, more rapid than that of *D. virginiana*.

Sharman (1959) has recorded the ages at which the pouch young of several species of marsupials reach a comparable stage of development. When these values are compared with those for the bandicoot, it will be seen that this animal develops more rapidly and becomes independent sooner than any of those studied so far. A comparison with three other Australian marsupials is set out in Table 3.

We have not, unfortunately, made observations on the length of the oestrous cycle. It is very difficult to make vaginal smears from bandicoots, or even to make smears from the urogenital sinus. Our only breeding female struggles violently during examination, and we have tried to reduce the amount of handling to a minimum.

VIII. Acknowledgments

We would like to thank Mr. D. Fleay, West Burleigh, Qld., for permission to examine three new-born bandicoots, and to quote from his observations on their birth after the mother's death. We are indebted to Mr. J. H. Pope of this Institute for the weights of captured bandicoots; to Dr. J. L. Harrison, of the Institute's Field Station, Innisfail, for valuable observations on parturition, for weights of captured animals, and also for helpful criticism of this paper; and to Miss A. van der Schans for help in caring for the animals.

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Addendum

Since this article was submitted for publication, two laboratory-bred bandicoots have produced young. One from litter 3 (No. 561 in Fig. 1) produced four babies in September, when she was 15 months old, and weighed about 1200 g; and one from litter 7 produced three babies in August, when she was $8\frac{1}{2}$ months old, and weighed about 900 g.

Explanation of Plates 1 and 2

Plate 1

Figs. 1–6.—Stages of growth of bandicoots during the first 7 weeks: *1*, 2 days; *2*, 8 days; *3*, 13 days; *4*, 23 days; *5*, 37 days; *6*, 49 days.

Plate 2

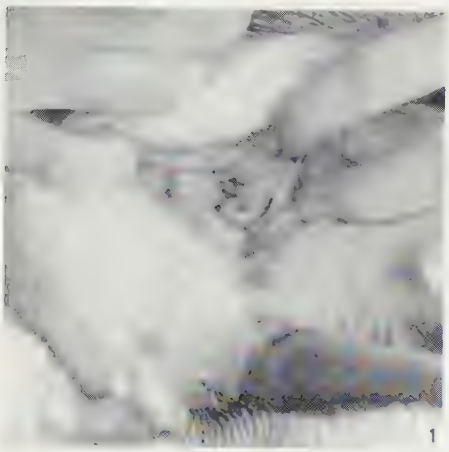
Fig. 1.—New-born, unattached bandicoot, photographed after preservation (scale in mm).

Fig. 2.—Bandicoot removed from teat less than 24 hr after birth, photographed alive (scale as in Plate 2, Fig. 1).

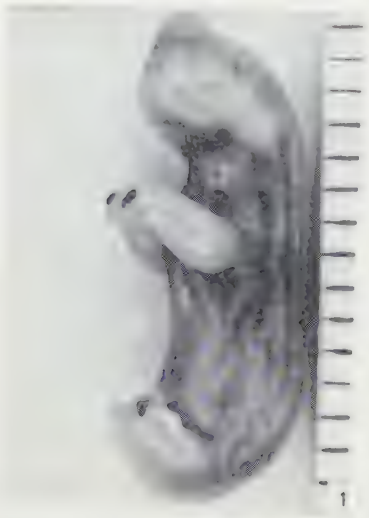
Fig. 3.—Bandicoot from litter 3 on 48th day (scale in inches).

Fig. 4.—Same as Plate 2, Figure 3. showing incomplete separation of lips.

BREEDING THE SHORT-NOSED BANDICOOT IN CAPTIVITY



BREEDING THE SHORT-NOSED BANDICOOT IN CAPTIVITY



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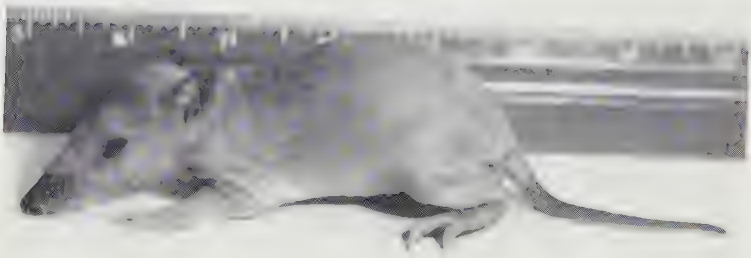

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4

ADDITIONAL INFORMATION ON THE AUSTRALIAN GENERA OF THE FAMILY PSYLLIDAE (HEMIPTERA: HOMOPTERA)

By K. L. Taylor*

[*Manuscript received June* 23, 1960]

Summary

The three species described by Signoret in the genus *Spondyliaspis* Sign. belong to two genera. As a result *Scenitopsylla* Tuthill & Taylor becomes a junior synonym of *Spondyliaspis*, two of Signoret's species are referred to *Cardiaspina* Crawf., and a new genus (*Glycaspis*) is erected for species assigned to *Spondyliaspis* by Schwarz, Froggatt, and other authors.

Another new genus (*Hyalinaspis*) is erected for *Cardiaspis rubra* Frogg., and *Uhleria* Crawf. is considered a junior synonym of *Lasiopsylla* Frogg. Because *Thea* Scott was preoccupied, a new name, *Phellopsylla*, is proposed for the genus containing species heretofore known under the name *Thea*.

Psylla lidgetti Mask. is considered to be correctly placed in the genus *Psylla* Geoff.; *Psylla subfasciata* Er. in the new genus *Hyalinaspis; Aphalara leptospermi* Frogg. in *Eucalyptolyma* Frogg. *Ascelis*(?) *multitudinea* Tepper, which was referred to *Trioza* Först. by Maskell, is now placed in the family Cecidomyidae (Diptera).

Introduction

Several important species of Australian psyllids were referred by their authors to the genus *Spondyliaspis* Signoret, 1879, and their placement has not previously been questioned. In order to determine the identity of *Psylla eucalypti* Dobson, which Schwarz (1898) referred to this genus, the three original species of *Spondyliaspis*, *S. spinosulus* Sign., *S. cereus* Sign., and *S. bancrofti* Sign. have been studied.

Additional information has been obtained, and much new material studied since the genera of Australian Psyllidae were reviewed by Tuthill and Taylor (1955). It is now possible to establish the relationships of most species they were unable to place, and several amendments to their paper must be made. A new name is required for the genus *Thea* Scott because the name *Thea* was preoccupied.

It should be noted that Signoret's three species were inadvertently omitted from the list of species given in Tuthill and Taylor's paper.

Genus SPONDYLIASPIS Signoret

Spondyliaspis Signoret, 1879, Ann, Soc. Ent. Fr. (5) **9**: Bulletin LXXXV.
Scenitopsylla Tuthill and Taylor, 1955, Aust. J. Zool. **3**: 241, fig. 10.

Type species (here designated) *Spondyliaspis bancrofti* Signoret, 1879.

Signoret (1879) erected the genus *Spondyliaspis* to receive three new species, *S. spinosulus*, *S. cereus*, and *S. bancrofti*. Although he wrongly assumed that his specimens belonged to the Aleurodidae, Signoret distinguished his genus by the shield or test which was in the form of a shell bearing several ribs or "fish-bones", spiny or smooth ("nous caractériserons ce groupe par son bouclier en forme de coquille

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présentant plusieurs côtes ou arêtes spinuleuses ou mutiques"). In his descriptions of the first two species, *S. spinosulus* and *S. cereus*, he stated that the shell was of a clear white wax, with spines on the ribs. *S. bancrofti* bore ribs and was rugose but not spiny. He did not have adult specimens associated with any of the three lerps.

A study of specimens from the type series of Signoret's three species, which are preserved in the Naturhistorisches Museum, Vienna, makes it clear that Schwarz (1898) and more recent authors have incorrectly interpreted Signoret's descriptions. These three species belong in fact to two genera. *S. spinosulus* and *S. cerus* are clearly congeneric with *Cardiaspis artifex* Schwarz, 1898, the type species of *Cardiaspina* Crawf., while *S. bancrofti* is congeneric with *Cardiaspis plicatuloides* Frogg., 1900, the type species of *Scenitopsylla* Tuthill & Taylor. The genus *Cardiaspina* is well established and includes several species of economic importance in Australia. so less confusion will be caused by selecting *S. bancrofti*, rather than either of the other two, as the type species of *Spondyliaspis*. *Scenitopsylla* thus becomes a junior synonym of *Spondyliaspis*.

An adequate description of this genus was given by Tuthill and Taylor (1955). The principal characters are: head wider than mesonotum, vertical; ocular sclerite strongly developed between vertex and eye, eyes thus definitely "stalked"; eyes elongate and strongly recessive; antennae longer than width of head; medial cell of forewing larger and longer than cubital.

In addition to *S. bancrofti* and *C. plicatuloides*, species placed in this genus are *Rhinocola nigra* Frogg., *R. mollis* Frogg., and *R. ostreata* Frogg.

Spondyliaspis bancrofti Signoret

Plate 1, Fig. 1

Spondyliaspis bancrofti Signoret, 1879, Ann. Soc. Ent. Fr. (5) **9**: Bulletin LXXXV.

Signoret did not have an adult specimen and gave only a brief description of the lerp. The following description of the lerp is based on a specimen from Signoret's type series:

Lerp.—Size 2·1 mm hinge to apex, 1·8 mm wide; colour uniformly brown; shape roughly hemispherical, constricted at sides near hinge; constructed in concentric layers from hinge outwards; 3 raised ribs arising from hinge, central one turned to left and matched by subsidiary rib on its right, a similar subsidiary arising on its left; further subsidiary ribs arising between all others near outer margin so that at the margin the lerp has a corrugated appearance.

Lectotype (lerp) "Dawson River, Queensland, auf Eucalyptus" from Signoret's type series (labelled "lectotype") in Naturhistorisches Museum, Vienna, hereby designated.

Genus GLYCASPIS,* gen. nov.

Plate 1, Figs. 2 and 3

Spondyliaspis sensu Schwarz (non Signoret, 1879), Schwarz, 1898, Proc. Ent. Soc. Wash. **4**: 68. Froggatt, 1900, Proc. Linn. Soc. N.S.W. **25**: 288. Tuthill and Taylor, 1955, Aust. J. Zool. **3**: 230, fig. 1.

* γλυκυς, sweet; ἀσπις, shield (= a sugary shield).

Type species (here designated) *Aphalara flavilabris* Froggatt, 1903.

Schwarz (1898), when studying specimens of Australian Psyllidae collected by Koebele, described some adult psyllids obtained from lerps which he presumed were similar to those described by Signoret (1879). He concluded that "the lerp from which Dobson obtained his species evidently agrees structurally with that upon which Signoret established his genus *Spondyliaspis*. . . . "

Dobson (1851) mentioned three species of the Psyllidae, but his name *Psylla eucalypti* clearly applies to the first of the three, which was illustrated in his figures 1, 2 (lerp only), 3*a*, and 4. Enquiries at all museums where type specimens are likely to have been deposited by Dobson indicate that no such specimens exist. There are in the British Museum some lerp specimens collected by Dobson, but they belong to one of the other species mentioned in his paper. They are labelled "*Psylla eucalypti*", but in the handwriting of a British Museum official of the period, not of Dobson. Specimens collected recently from *Eucalyptus viminalis* Labill. in the Domain, Hobart, Tas., are considered to be Dobson's species *P. eucalypti*, and belong to this genus. The species described by Schwarz (1898) as "*Spondyliaspis eucalypti* Dobson (?)" which was collected by Koebele from *Eucalyptus leucoxylon* F. Muell., probably in South Australia, is congeneric but is certainly not *P. eucalypti*.

Full descriptions of the genus are given in the papers cited above. The principal characters are: the large genal processes, from two-thirds as long as to longer than the vertex; antennae much longer than width of head; forewing longer, angulate apically, with short basal vein and short petiole of media and cubitus; *Rs* very long, reaching apex of wing, curved parallel to costal margin; metatibia shorter than femur, enlarged apically with lateral protuberance on one side bearing 2 black spurs, another group of black spurs on opposite side; proximal segment of metatarsus enlarged, broad, and curved.

In addition to the type species the following are placed in this genus: *Spondyliaspis mannifera* Frogg., *S. hirsutus** Frogg., *S. nigrocincta* Frogg., *S. granulata* Frogg., *S. occidentalis* Solomon, and *Psylla eucalypti* Dobson.

Genus EUCALYPTOLYMA Froggatt

Eucalyptolyma Froggatt, 1901, Proc. Linn. Soc. N.S.W. **26**: 262. Tuthill and Taylor, 1955, Aust. J. Zool. **3**: 231, fig. 2

Type species (original designation) *Eucalyptolyma maideni* Froggatt, 1901.

A specimen from the type series of Froggatt's species *Aphalara leptospermi* deposited in the New South Wales Department of Agriculture Collection is in a much better state of preservation than those in Froggatt's Collection, Division of Entomology Museum, C.S.I.R.O., Canberra. An examination of this specimen establishes that *A. leptospermi* belongs to the genus *Eucalyptolyma*. This specimen (labelled "Frankston, Victoria, C. French Jr. on *Leptospermum laevigatum*, 16.x.1902") is hereby designated as the lectotype of *leptospermi* and has been labelled as such. Fresh specimens of this species were collected from *Leptospermum laevigatum* (Soland. ex

* The specific name should be rendered in the feminine form, *hirsuta*.

Gaertn.) F. Muell. in 1956 by Mr. T. G. Campbell at the type locality (Frankston) and are in the Division of Entomology Museum.

Genus LASIOPSYLLA Froggatt

Lasiopsylla Froggatt, 1900, Proc. Linn. Soc. N.S.W. **25**: 261. Tuthill and Taylor, 1955, Aust. J. Zool. **3**: 234, fig. 4.

Uhleria Crawford, 1914, Bull. U.S. Nat. Mus. **85**: 106.

Type species (original designation) *Lasiopsylla rotundipennis* Froggatt, 1900.

Crawford (1914) described a new species *Uhleria mira* for which he erected the genus *Uhleria*, from one female specimen with no locality data. He wrote that it was probably an American species but his description and figures (114, 115, 411) suggested to the present author that it belonged to Froggatt's genus *Lasiopsylla*. Heslop-Harrison (1954, p. 527) also noticed that this genus had "all the ear-marks of being an introduced Australian genus". Specimens of *L. rotundipennis* were compared with *U. mira* by Miss Louise Russell at the United States National Museum, who confirmed that these two species were congeneric.

Adult specimens of *L. falcatus** Frogg. are still not available, so the placing of this species must remain in doubt.

Genus CARDIASPINA Crawford

Fig. 1*A*; Plate 1, Figs. 4 and 5

Cardiaspina Crawford, 1911, Pomona Coll. J. Ent. **3**: 632. Tuthill and Taylor, 1955, Aust. J. Zool. **3**: 235, fig. 5.

Cardiaspis Schwarz, 1898 (non Amyot, 1846), Proc. Ent. Soc. Wash. **4**: 72. Froggatt, 1900, Proc. Linn. Soc. N.S.W. **25**: 281.

Pennapsylla Froggatt, 1923, Forest Insects of Australia, coloured plate.

Type species (original designation) *Cardiaspis artifex* Schwarz, 1898.

Head not wider than mesoscutum, vertical. Vertex flat, depressed discally. Ocular sclerite visible as small lobe between eye and base of antenna. Genal processes stout, swollen, obliquely truncate in most species, more or less contiguous. Eyes rounded, not recessive or very slightly so. Antennae short, mostly shorter than width of head. Thorax rather flat except anteriorly where curved down to head. Pronotum long, broad. Forewing long, narrowly rounded apically; media and cubitus with common petiole; subcosta absent and costa never greatly thickened; small open pterostigma; *Rs* nearly straight, reaching almost to apex of wing; marginal cells nearly equal, medial triangular. Legs stout, femora enlarged. Metacoxa swollen, without meracanthus. Metatibia flaring apically, either with continuous row of spurs around anterior half or with several close together on outside edge, remainder fairly evenly spaced. Claws on proximal segment of metatarsus very small.

This is the only genus in which the lerps (of some species) are constructed in the form of a network, those in all other genera being solid plates or shells. Most species of *Cardiaspina* which do not build a network tend to construct the lerp by cementing together a series of small plates.

* The specific name should be rendered in the feminine form, *falcata*.

The most important characters used to distinguish the genus are the short robust body, the triangular medial cell, the vertical head, which is narrower than the mesoscutum, and the short antennae. The lerps are also characteristic in most species.

Cardiaspis rubra Frogg., which was left in this genus by Tuthill and Taylor (1955), is now assigned to the new genus *Hyalinaspis* described hereafter. In addition to the other species assigned to *Cardiaspina* by Tuthill and Taylor, *Spondyliaspis spinosulus** and *S. cereus** (see p. 383) are now placed in this genus. It is possible that these two species are conspecific but it will be necessary to collect further material to establish this. One specimen from Signoret's type series of *S. spinosulus* (labelled

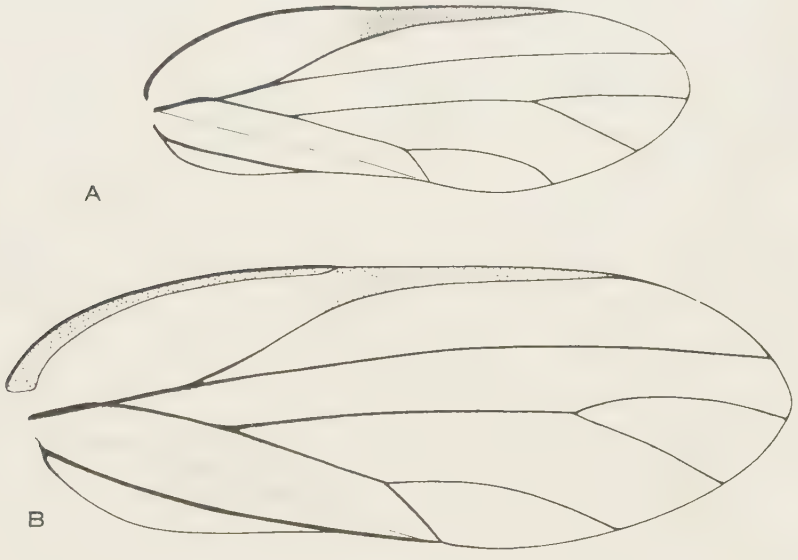

Fig. 1.—*A*, *Cardiaspina* Crawf., forewing (based on undescribed species); *B*, *Hyalinaspis*, gen. nov., forewing (based on *H. rubra* (Frogg.)).

"Brisbane, Queensland, auf *Eucalyptus*") is hereby selected as lectotype of *S. spinosulus*, and one from his type series of *S. cereus*, bearing identical labels, as lectotype of *S. cereus*. Both specimens are lerps and bear Signoret's determination labels. Lectotype labels have been affixed to each.

Genus HYALINASPIS,† gen. nov.

Fig. 1*B*, Plate 1, Fig. 6

Type species (here designated) *Cardiaspis rubra* Froggatt, 1903.

Head narrower than mesoscutum, vertical. Vertex flat, depressed discally. Ocular sclerite visible as small segment between eye and base of antenna. Genal processes stout, cylindrical, rounded or slightly truncate apically, more or less contiguous. Eyes rounded, not recessive. Antennae longer than width of head. Thorax

* The specific names should be rendered in the feminine forms, *spinosula* and *cerea*.

† ὑάλινος, glassy; ασπις, a shield (= a glassy shield).

rather flat. Pronotum short, flat. Forewing long, narrowly rounded apically; media and cubitus with common petiole; subcosta present though sometimes almost fused with costa; small open pterostigma; *Rs* nearly straight, reaching almost to apex of wing; marginal cells about equal, medial triangular. Legs stout, femora enlarged. Metacoxa swollen, without meracanthus. Metatibia flaring apically, with small group of spurs on outside margin, and others more widely spaced on ventromedial margin. Claws on proximal segment of metatarsus lacking or very small.

The lerps of *H. rubra* and certain undescribed species in the Division of Entomology Museum, C.S.I.R.O., Canberra, are all solid in contrast with those of *Cardiaspina*, and mostly transparent. They are constructed by the addition of concentric layers of exudation.

This genus differs from *Cardiaspina* by the presence of the subcosta, by the longer antennae (longer than width of head), and by the form of the lerp.

Psylla subfasciata Er. is placed in this genus, though it is doubtful whether it will ever be possible to recognize the species. Erichson (1842) described two species from Tasmania, *P. luteola* and *P. subfasciata*. In 1955, Dr. St. v. Keler of the Berlin Museum advised that the type specimens of these two species had been deposited in that Museum. That of the former species was completely destroyed, but he had prepared a slide of the remnants of *P. subfasciata*, which he kindly sent on loan for examination.

Genus PHELLOPSYLLA,* nom. nov.

Thea Scott, 1882 (non Mulsant, 1846, non Albers, 1850), Trans. Ent. Soc. Lond. **1882**: 450. Froggatt, 1900, Proc. Linn. Soc. N.S.W. **25**: 295. Tuthill and Taylor, 1955, Aust. J. Zool. **3**: 237, fig. 7.

Type species (original designation) *Psylla trigutta* Walker, 1858.

The most important characters of this genus are the broad head, with slightly recessive eyes; ocular sclerite produced anteriorly as a large lobe between eye and base of antenna, genal processes very short and broad, ribbon-like; antennae equal to or longer than width of head; pronotum long, flat; forewing very narrowly rounded or obliquely truncate apically; costal margin with distinct break or notch at base of pterostigma; pterostigma short, very broad; *Rs* reaching or almost reaching apex of wing.

Full descriptions (as *Thea*) are given by the authors cited above. Species placed in this genus are those placed in *Thea* by Tuthill and Taylor (1955): viz. *Psylla trigutta* Walk. *Thea formicosa* Frogg., *T. opaca* Frogg., *T. leai* Frogg., *T. olivacea* Frogg., and *T. wellingtoniae* Frogg.

Mr. E. F. Riek examined the type specimen of *Phyllolyma fracticosta* (Walk.) on behalf of the author at the British Museum in 1955, and compared it with specimens of this genus and *Cometopsylla* Frogg. His notes suggest that it is doubtful whether all three genera should be retained, but they will not be disturbed until more detailed studies can be made.

* φελλος, bark + psylla (= bark psylla).

Genus PSYLLA Geoffroy

Psylla Geoffroy, 1762, Histoire Abrégée des Insectes **1**: 482. Loew, 1878, Verh. zool.-bot. Ges. Wien **28**: 600. Froggatt, 1901, Proc. Linn. Soc. N.S.W. **26**: 243.

With the qualification stated by Tuthill and Taylor (1955) for other Australian species, and after further study of the paper by Maskell (1898), *Psylla lidgetti* Mask. is retained in this genus for the present. Efforts have been made to locate a type specimen in the most likely museums, but with no success.

Genus TRIOZA Förster

Trioza Förster, 1848, Verh. naturh. Ver. preuss. Rheinl. **5**: 67.

Tepper's specimens of *Ascelis*(?) *multitudinea* Tepper, 1893, which are in the South Australian Museum, have been examined. This species was placed in *Trioza* by Maskell (1898) on the basis of his examination of adults bred from galls sent to him by Tepper. It appears, however, that Tepper sent him material of a different species and that Maskell did not see the pinned specimens on which Tepper (1893, p. 278) had based his description.

The specimens described by Maskell belonged to the Psyllidae. His descriptions of the adult, nymph, and gall leave no doubt that they were a species of *Schedotrioza* Tuthill & Taylor which contains all of the triozine psyllids forming galls on *Eucalyptus* spp. Efforts to locate the specimens described by Maskell have been unsuccessful. *A.*(?) *multitudinea*, however, does not belong to the Psyllidae. The galls he described were more spongy than those of *Schedotrioza* spp. and possessed an apical aperture which is not present in *Schedotrioza* spp. The larva he figured (Tepper 1893, pl. V, fig. 4d) is preserved and has been examined by Mr. E. F. Riek, who states that it belongs to the Cecidomyidae (Diptera). Mr. Riek also comments that the galls associated with this specimen are typical cecidomyid galls.

The specimen of the larva, which is mounted on a cardboard point, above another specimen of indeterminate structure, is hereby selected as the lectotype of *A.*(?) *multitudinea*, and has been labelled as such. The label on the pin bears the following data in Tepper's handwriting: "*Ascelis*(?) *multitudinea* sp. nov., Marino S.E., March 85, A. Molineux". The name was subsequently altered, probably by Tepper, to read "*Trioza multitudinea* (Tepp.) Mask.".

Acknowledgments

The author acknowledges with thanks the help of Dr. Max Beier, Naturhistorisches Museum, Vienna, for lending him specimens of Signoret's three species; Dr. St. v. Keler, Berlin Museum, for information about Erichson's two species and for the loan of the slide of *Psylla subfasciata* Er.; Miss Louise Russell, United States National Museum, for comparing specimens with *Uhleria mira* Crawf.; Mr. G. F. Gross, South Australian Museum, for arranging the loan of Tepper's specimens; Mr. E. F. Riek for examination of specimens in the British Museum and of *Ascelis*(?) *multitudinea;* Dr. V. F. Eastop for pointing out that the name *Thea* Scott was preoccupied, and for other valuable advice; Mr. K. M. Moore for criticism of the manuscript; and Mr. L. Marshall and Mr. D. Wilson for preparation of the illustrations

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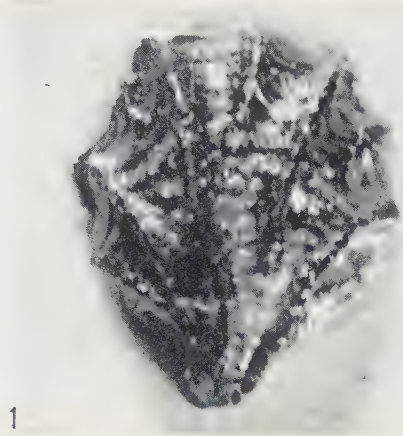
List of Species

Genus under which species is described is in parentheses, present disposition at right

artifex Schwarz (*Cardiaspis*)	*Cardiaspina* Crawf.	386
bancrofti Sign. (*Spondyliaspis*)	*Spondyliaspis* Sign.	384
cerea Sign. (*Spondyliaspis*)	*Cardiaspina* Crawf.	387
eucalypti Dobson (*Psylla*)	*Glycaspis*, gen. nov.	385
flavilabris Frogg. (*Aphalara*)	*Glycaspis*, gen. nov.	385
formicosa Frogg. (*Thea*)	*Phellopsylla*, nom. nov.	388
fracticosta Walk. (*Psylla*)	*Phyllolyma* Scott	388
granulata Frogg. (*Spondyliaspis*)	*Glycaspis*, gen. nov.	385
hirsuta Frogg. (*Spondyliaspis*)	*Glycaspis*, gen. nov.	385
leai Frogg. (*Thea*)	*Phellopsylla*, nom. nov.	388
leptospermi Frogg. (*Aphalara*)	*Eucalyptolyma* Frogg.	385
lidgetti Mask. (*Psylla*)	*Psylla* Geoff.	?89
luteola Er. (*Psylla*)	(?)	388
maideni Frogg. (*Eucalyptolyma*)	*Eucalyptolyma* Frogg.	385
mannifera Frogg. (*Spondyliaspis*)	*Glycaspis*, gen. nov.	385
mira Crawf. (*Uhleria*)	*Lasiopsylla* Frogg.	386
mollis Frogg. (*Rhinocola*)	*Spondyliaspis* Sign.	384
multitudinea Tepper (*Ascelis*?)	Diptera: Cecidomyidae	389
nigra Frogg. (*Rhinocola*)	*Spondyliaspis* Sign.	384
nigrocincta Frogg. (*Spondyliaspis*)	*Glycaspis*, gen. nov.	385
occidentalis Solomon (*Spondyliaspis*)	*Glycaspis*, gen. nov.	385
olivacea Frogg. (*Thea*)	*Phellopsylla*, nom. nov.	388
opaca Frogg. (*Thea*)	*Phellopsylla*, nom. nov.	388
ostreata Frogg. (*Rhinocola*)	*Spondyliaspis* Sign.	384

ADDITIONAL INFORMATION ON AUSTRALIAN PSYLLIDAE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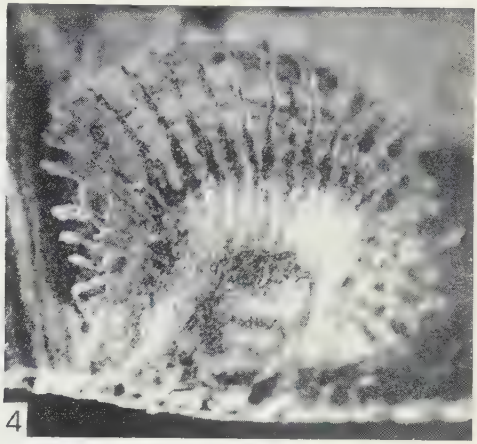
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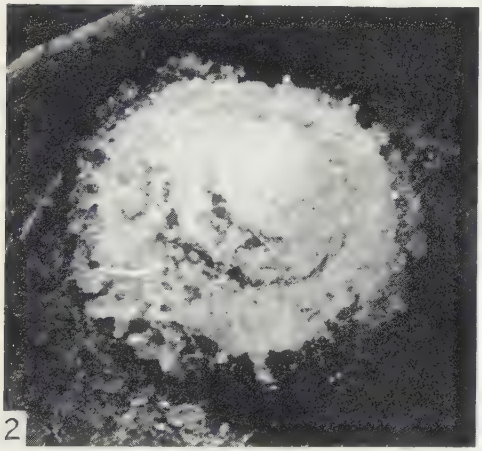
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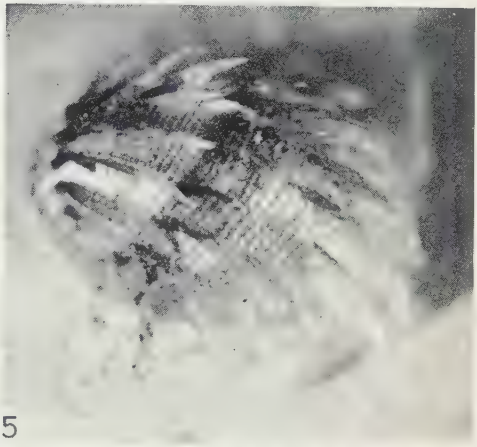
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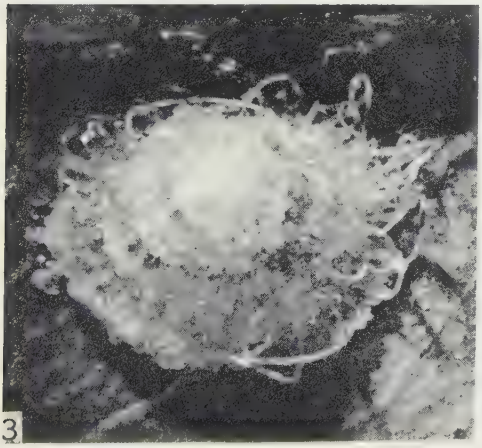
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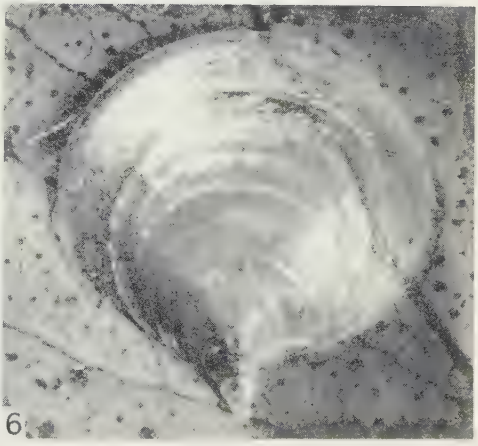
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Explanation of Plate 1

Plate 1

Fig. 1.—*Spondyliaspis bancrofti* Sign., lerp. ×*c.* 24.
Fig. 2.—*Glycaspis eucalypti* (Dobson), lerp. ×*c.* 13.
Fig. 3.—*Glycaspis* sp. (undescribed), lerp. Note waxy filaments. ×*c.* 11.
Fig. 4.—*Cardiaspina artifex* (Schwarz), lerp. ×*c.* 11.
Fig. 5.—*Cardiaspina spinosula* (Sign.), lerp. ×*c.* 13.
Fig. 6.—*Hyalinaspis rubra* (Frogg.), lerp. ×*c.* 9.

A SYSTEMATIC STUDY OF THE AUSTRALIAN SPECIES OF THE GENUS *IXODES* (ACARINA: IXODIDAE)

By F. H. S. Roberts*

[*Manuscript received June* 10, 1960]

Contents

Summary

A systematic study has been made of the species of *Ixodes* (Ixodidae) occurring in Australia.

Nineteen species were recognized in the material available for examination, namely *I. uriae*, *I. kohlsi*, *I. eudyptidis*, *I. pterodromae*, *I. simplex simplex*, *I. vespertilionis*, *I. ornithorhynchi*, *I. tasmani*, *I. hydromyidis*, *I. australiensis*, *I. victoriensis*, *I. fecialis*, *I. antechini*, *I. vestitus*, *I. holocyclus*, *I. confusus*, *I. cornuatus*, *I. hirsti*, and *I. trichosuri*. Four of these, *I. antechini*, *I. cornuatus*, *I. confusus*, and *I. trichosuri*, are regarded as new species and *I. simplex simplex* and *I. pterodromae* are recorded from Australia for the first time. *I. rothschildi* recorded by Arthur (1953) from Western Australia was not encountered.

A detailed description with appropriate figures is given for each species, including all known stages in the life cycle, together with data on host range and geographical distribution. Keys are supplied for the known males, females, nymphs, and larvae and a classified host list has been compiled.

Introduction

The revision of the world species of *Ixodes* by Neumann (1899) included three species from Australia, namely *I. ornithorhynchi* Lucas, *I. tasmani*, and *I. holocyclus*, the last two being described for the first time. Two further new species were added by this worker, *I. australiensis* in 1904 and *I. restitus* in 1908, and Warburton and Nuttall described *I. fecialis* and its variety *I. fecialis aegrifossus* in 1909. Two years later Nuttall and Warburton (1911) contributed their section on the genus *Ixodes* in their classical monograph "Ticks, a Monograph of the Ixodoidea" in

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which they recognized all the above species and also *I. vespertilionis* Koch. They also referred to *I. uriae* White (*I. putus* Pickard-Cambridge) recorded by Neumann (1911) from King I., Tas., which Neumann considered as being in British Columbia, but was noted by Nuttall and his colleague as "?Tasmania."

Further records by Nuttall (1916) referred to the synonymy of *I. fecialis aegrifossus* with *I. fecialis*, to the occurrence of *I. percavatus* Neumann and *I. eudyptidis* Maskell on sea birds, and to a new species, *I. victoriensis*, from the wombat.

Three more species have since been described, namely, *I. hirsti* Hassall, 1931 (*I. victoriensis* Hirst, 1930), *I. hydromyidis* Swan, 1931, and *I. kohlsi* Arthur, 1955, and Arthur (1953) recorded the presence of *I. rothschildi* Nuttall & Warburton, 1911.

Schulze (1935) in an account of species from Australia and New Guinea concluded that the tick identified by Ross (1924) as *I. holocyclus*, and on which Ross based his excellent observations on the biology of this species and of the paralysis it causes in the dog, was not *I. holocyclus* of Neumann (1899) and referred Ross' specimens to a new species *I. rossianus*. Schulze also considered that two subspecies of *I. tasmani* were present which he called *I. tasmani tasmani* and *I. tasmani victoriae*.

Accounts of the Australian species have also been contributed by Rainbow (1906), Ferguson (1925), Fielding (1926), and by Taylor and Murray (1946). These were based mainly on the literature, but added several new host and locality records.

When these studies were commenced then the following species had been recorded from Australia: *I. tasmani* (subspecies *I. tasmani tasmani* and *I. tasmani victoriae*), *I. ornithorhynchi*, *I. holocyclus*, *I. rossianus*, *I. hirsti*, *I. vestitus*, *I. fecialis*, *I. australiensis*, *I. hydromyidis*, *I. victoriensis*, *I. kohlsi*, *I. rothschildi*, *I. percavatus*, *I. uriae*, *I. eudyptidis*, and *I. vespertilionis*.

The material studied by the author did not include *I. rothschildi*. Four new species were present which have been called *I. antechini*, *I. confusus*, *I. cornuatus*, and *I. trichosuri*, and two species not hitherto recorded from Australia, namely *I. simplex simplex* Neumann, and *I. pterodromae*, were identified. The most abundant species was *I. holocyclus* (see p. 459 for synonymy of *I. rossianus* with this species) which is not surprising as it has a wide distribution and is notorious as a cause of serious paralysis in domestic animals and man. *I. tasmani* was also well represented as were also *I. hirsti*, *I. trichosuri*, *I. fecialis*, *I. ornithorhynchi*, and *I. kohlsi*. Only a small number of specimens of *I. australiensis*, *I. victoriensis*, *I. vestitus*, *I. hydromyidis*, *I. pterodromae*, *I. simplex simplex*, and *I. eudyptidis* was seen. Australian specimens of *I. uriae* were also few, but a good series from Heard and Macquarie Is. was available. Males of only *I. holocyclus* were seen in good numbers and this sex in *I. ornithorhynchi*, *I. victoriensis*, *I. australiensis*, *I. hydromyidis*, *I. vestitus*, *I. pterodromae*, and *I. simplex simplex* remains undescribed. The nymphs and larvae of several species were recognized but here again these stages in other species remain unknown.

The biology of *I. holocyclus* has been studied extensively, and an excellent summary of these studies is given by Seddon (1951). Other than the species recorded from sea birds, the Australian species appear to have been collected mainly from animals. The avian host records include *I. holocyclus*, female, nymph, and larva, from the domestic fowl and duck, the female from the crow, *Corvus coronoides*, and the nymph from the dragoon bird, *Pitta* sp., nymphs of an undetermined species (*I. hirsti?*) from the pilot bird, *Pycnoptilus floccosus*, and an undetermined larva (*I. hirsti?*) from the scrub-wren *Sericornis frontalis*. The only species recorded from man are *I. holocyclus* (male (crawling), female, nymph, larva), *I. cornuatus* (female), *I. kohlsi* (nymph), *I. tasmani* (female), and *I. confusus* (female). Species attacking domestic animals include *I. holocyclus* (all domestic animals), *I. tasmani* (horse, dog, cat), *I. hirsti* (cat), *I. cornuatus* (dog, cat), and *I. australiensis* (dog, cow). Only two species have been recorded from Reptilia, namely, *I. vestitus* from the brown snake, *Demansia textilis*, and *I. ornithorhynchi* from the blue-tongued lizard.

The genus *Ixodes* includes several species in various parts of the world which are vectors of important diseases of man and domestic animals, but in Australia only *I. holocyclus* has been implicated in this regard. This species is an experimental vector of Q-fever (*Coxiella burneti* (Derrick)), which it can transmit from stage to stage. It is best known, however, by its ability to cause a serious and frequently fatal condition of paralysis in man and the domestic animals (Seddon 1951).

The morphological terms used throughout are in conformity with the definitions set down by Nuttall and Warburton (1911) and by Cooley and Kohls (1945). The lateral grooves in the male are seen in only a few species, running inside the edge of the scutum and giving the species double dorsal folds (e.g. *I. holocyclus*). In some species, these grooves are represented anteriorly by carinae, usually mild (e.g. *I. hirsti*). The anteroposterior ridges which are apparent on the dorsal, and sometimes also on the ventral surfaces of the basis capituli, are also referred to as carinae. All measurements are given in millimetres. Body length has been taken from the tip of the scapulae to the caudal margin, and the width of the basis capituli as the maximum width, but not including palpal article 1. Dimensions of the scutum include the length from the tip of the scapulae to the level of the margin of the posterior angle, and the width as the greatest width across the scutum.

Drawings were made with a compound microscope aided by a camera lucida. Whenever possible whole ticks preserved in alcohol were used, care being taken not to allow the specimens to dry out. Drawings of the hypostomes and of some of the larvae relied on mounts.

The material examined came from the collections of the Animal Research Institute, Department of Agriculture and Stock, Queensland; the Queensland Institute of Medical Research; the Queensland Museum; the Department of Entomology, University of Queensland; the Australian Museum; the School of Public Health and Tropical Medicine, University of Sydney; the McMaster Laboratory, C.S.I.R.O. (Mr. M. D. Murray); Wildlife Survey Section, C.S.I.R.O., Canberra; the National Museum of Victoria; the Victorian Department of Agriculture; the South Australian Museum; the Western Australian Museum; the Western Australian Department of Agriculture; and the Tasmanian Museum.

Genus IXODES Latreille

Type species *Ixodes ricinus* (Linnaeus) Latreille, 1804.

Definition.—Inornate and without eyes or festoons: anal grooves surrounding anus anteriorly and usually uniting in a point or arch; tarsi rarely with spurs; spiracular plate round or oval; male scutum surrounded by a usually prominent body fold and male venter with 7 well-defined, non-salient chitinous plates, namely 1 pregenital, 1 median, 1 anal, 2 adanal, and 2 epimeral; sexual dimorphism frequently marked, especially in the palpi and hypostome.

The synonymy of *Ixodes* is given by Nuttall and Warburton (1911), by Cooley and Kohls (1945), and by Kohls (1957*a*) and includes *Ceratixodes* and *Eschatocephalus*. *Ceratixodes* was created by Neumann (1902) for *I. uriae* (= *I. putus* Pickard-Cambridge), but was later degraded by him (1904) to a subgenus. *Eschatocephalus* Frauenfeld, 1853, was retained by Neumann (1902) for *I. vespertilionis* L. Koch, but was also subsequently relegated to a subgenus (Neumann 1904). *Ceratixodes* has since been recognized as a genus by a number of workers including Schulze (1941), Zumpt (1952), and Arthur (1956*b*). Pomerantzev (1950) regarded it as a subgenus but Kohls (1957*a*) listed it simply as a synonym of *Ixodes*. *Eschatocephalus* was given subgeneric rank by Pomerantzev (1950) and Arthur (1956*b*), while Schulze (1935) considered it worthy of generic status.

Schulze (1935) created additional subgenera including *Sternalixodes*, *Endopalpiger*, *Exopalpiger*, and *Lepidixodes*.* Later, this worker (1941) divided the Prostriata into two groups, mainly on the structure of Haller's organ, and these he called the Thecorina, or capsule-nosed ticks, and the Phynorhina or trough-nosed ticks. Schulze further contended that trough-nosed species hitherto in the genus *Ixodes* must be renamed and proceeded to define the genera *Coxixodes*, which was based on *I. ornithorhynchi*, *Scaphixodes*, and *Xiphixodes*. Arthur (1956*b*), who studied the details of Haller's organ in many species of *Ixodes*, considered firstly that while such a broad classification into the Thecorina and Phynorhina was valid for British ticks it was not universal, and secondly that any attempt to apply Schulze's classification to all ticks with trough-nosed capsules would result in a number of genera each with a single species. Kohls (1957*a*) also considered there was little reason for recognizing *Coxixodes*, *Scaphixodes*, and *Xiphixodes* and remarked "The type and only contained species of each of these exhibit unusual morphological patterns, but I do not regard these species as sufficiently distinct to require the splitting up of the old and well-established parent genus."

The Australian species fall into well-defined groups which come within the definitions of *Sternalixodes*, *Endopalpiger*, *Exopalpiger*, and *Ixodes* s.s. *I. holocyclus*, *I. cornuatus*, *I. confusus*, *I. hirsti*, and *I. trichosuri* belong to *Sternalixodes*. These have a sternal plate in the female or nymph.† The females possess a large scutum,

* *Lepidixodes* was created for *I. kopsteini* Koch. Anastos (1950) considered this species to be a special kind of mite and saw no reason for regarding it as a tick, let alone a species of *Ixodes*.

† Schulze (1935) reported a sternal plate also in the nymph of *I. prissicollaris*, the type of his subgenus *Exopalpiger*.

which in unfed specimens covers a large area of the dorsum, strong scutal carinae, an elongate lanceolate hypostome, long slender palpi, armed coxae, and anal grooves which are closed behind. The males are all very similar morphologically with lateral grooves, and an anal plate bluntly pointed posteriorly.

I. victoriensis, *I. australiensis*, *I. tasmani*, and *I. hydromyidis* all belong to *Endopalpiger*, and are characterized by the greatly enlarged article 1 of the palpi, which extends inwardly and anteriorly to ensheathe the basal area of the mouthparts, and is salient laterally, particularly ventrally. All have relatively broad scuta and scutal lateral carinae are absent.

Exopalpiger includes *I. fecialis*, *I. vestitus*, and *I. antechini* with palpal article 1 enlarged and inserted diagonally on the basis capituli with which it is fused. This article is strongly salient laterally but extends at most only a short distance inwardly. The basis is furnished with carinae as is also the scutum. The coxae are unarmed except in *I. antechini* and possess posterior membranous outgrowths (syncoxae).

The remaining species belong to the subgenus *Ixodes* s.s.

Key to the Australian Species of the Genus Ixodes

*Males**

1. Body with 5 posterior brushes of hairs (sea bird habitats) ..... *I. uriae*
   Body without such brushes of hairs 2
2(1). Legs inordinately long, much longer than body (bat habitats) ..... *I. vespertilionis*
   Legs not as above 3
3(2). Lateral grooves distinct but not necessarily complete 4
   Lateral grooves absent 8
4(3). Scutum with lateral carinae 5
   Scutum without lateral carinae 6
5(4). Trochanters with spurs ..... *I. confusus*
   Trochanters devoid of spurs ..... *I. hirsti*
6(4). Lateral grooves completely encircling scutum, or almost so 7
   Lateral grooves apparent posteriorly only ..... *I. trichosuri*
7(6). Body measurements at least 3·0 by 2·5 mm ..... *I. cornuatus*
   Body measurements less than 3·0 by 2·5 mm ..... *I. holocyclus*
8(3). Article 1 of palpi greatly enlarged, extending inwardly and anteriorly to ensheathe base of mouthparts ..... *I. tasmani*
   Article 1 of palpi not as above 9
9(8). Anal plate constricted medianly; hypostome bilobed distally, dentition greatly reduced (sea bird habitats) ..... *I. kohlsi*
   Anal plate not constricted medianly; hypostome and dentition not as above 10
10(9). Small, narrowly oval ticks, hypostome dentition 2/2 11
   A medium-sized, broadly oval tick; hypostome dentition mainly 4/4 and 3/3 (sea bird habitats) ..... *I. rothschildi*
11(10). Coxa I with a small external spur ..... *I. antechini*
   Coxa without such a spur ..... *I. fecialis*

* The males of *victoriensis*, *australiensis*, *hydromyidis*, *vestitus*, *ornithorhynchi*, *eudyptidis*, *pterodromae*, and *simplex simplex* have not been described.

Females

1. Legs inordinately long, giving a spidery effect ..... *I. vespertilionis*
Legs not as above 2

2(1). Anal grooves meeting posteriorly 3
Anal grooves widely separated posteriorly 8

3(2). Palpal article 1 greatly enlarged, ensheathing base of mouthparts, capitulum short ..... *I. australiensis*
Palpal article 1 not as above; capitulum long 4

4(3). Sternal plate present 5
Sternal plate absent 7

5(4). Coxae with ridges 6
Coxae smooth ..... *I. trichosuri*

6(5). Basis capituli with 3 carinae dorsally and ventrally; trochanters with spurs ..... *I. confusus*
Basis capituli with only 2 carinae dorsally and ventrally; trochanters without spurs ..... *I. hirsti*

7(4). Basis capituli with well-defined bluntly pointed cornua ..... *I. cornuatus*
Basis capituli with at most only shallow rounded cornua ..... *I. holocyclus*

8(2). Hypostome dentition 2/2 9
Hypostome dentition more than 2/2, particularly in distal area 12

9(8). Scutum widest anteriorly, palpal article 3 broader than palpal article 2 (sea birds) ..... *I. uriae*
Scutum widest towards or posterior to mid-length, palpal article 3 not broader than palpal article 2 10

10(9). Scutum wider than long and widest towards mid-length ..... *I. vestitus*
Scutum longer than wide and widest posteriorly 11

11(10). Palpal article 1 triangular, scutum only a little longer than wide; coxa I unarmed ..... *I. fecialis*
Palpal article 1 somewhat rectangular, scutum almost twice as long as wide, coxa I with small, but distinct, external spur ..... *I. antechini*

12(8). Palpal article 1 greatly enlarged and ensheathing base of mouthparts 13
Palpal article 1 not as above 15

13(12). Basis capituli with cornua; coxae with spurs ..... *I. victoriensis*
Basis capituli without cornua; coxae without spurs 14

14(13). Scutum a little longer than wide, punctations fine; porose areas superficial ..... *I. hydromyidis*
Scutum wider than long, punctations numerous and relatively coarse; porose areas well defined ..... *I. tasmani*

15(12). Coxae with spurs (sea birds) 17
Coxae without spurs 16

16(15). Scutum longer than wide; hypostome dentition with 4 rows of 3/3 (bats) ..... *I. simplex simplex*
Scutum wider than long; hypostome dentition with about 7–8 rows of 3/3 ..... *I. ornithorhynchi*

17(15). Article 1 of palpi with a strong, internal, anteriorly directed, horn-like protrusion and a distinct mesodorsal spur (sea birds) ..... *I. pterodromae*
Article 1 of palpi not as above 18

18(17). Basis capituli with cornua 19
Basis capituli without cornua ..... *I. eudyptidis*

19(18). Anal grooves markedly constricted posteriorly (sea birds) ..... *I. kohlsi*
Anal grooves at most only slightly constricted posteriorly (sea birds) ..... *I. rothschildi*

*Nymphs**

1. Legs inordinately long, giving a spidery effect (bats) ..... *I. vespertilionis*
Legs not as above 2
2(1). Sternal plate present 3
Sternal plate absent 4
3(2). Anal grooves narrowly open posteriorly; hypostome bluntly pointed, dentition 3/3 and 2/2 ..... *I. holocyclus*
Anal grooves closed posteriorly; hypostome acutely pointed, dentition 2/2 ..... *I. trichosuri*
4(2). Scutum with lateral carinae 5
Scutum without lateral carinae 8
5(4). All coxae with spurs (sea birds) ..... *I. rothschildi*
At most only coxa I with spur 6
6(5). Scutum much longer than wide; coxa I with a small but distinct external spur ..... *I. antechini*
Scutum at most little longer than wide; coxa I unarmed 7
7(6). Article 1 of palpi triangular ..... *I. fecialis*
Article 1 of palpi somewhat discoidal ..... *I. vestitus*
8(4). Palpal article 1 greatly enlarged and ensheathing base of mouthparts 9
Palpal article 1 not as above 11
9(8). Coxae armed ..... *I. australiensis*
Coxae unarmed 10
10(9). Scutum with few and fine punctations; cervical grooves not attaining posterior margin of scutum ..... *I. hydromyidis*
Scutum with numerous, relatively coarse punctations; cervical grooves running full length of scutum ..... *I. tasmani*
11(8). Palpal article 1 extending inwardly and anteriorly as a well-developed spur (sea birds) ..... *I. pterodromae*
Palpal article 1 without such a spur 12
12(11). Coxae armed 13
Coxae unarmed 14
13(12). Basis capituli with cornua (sea birds) ..... *I. kohlsi*
Basis capituli without cornua (sea birds) ..... *I. eudyptidis*
14(12). Hypostome dentition with rows at most 2/2 15
Hypostome dentition with rows of 3/3 (bats) ..... *I. simplex simplex*
15(14). Palpal article 3 wider than palpal article 2; scutum with greatest width anteriorly (sea birds) ..... *I. uriae*
Palpal article 3 not wider than palpal article 2; scutum with greatest width near mid-length ..... *I. ornithorhynchi*

Larvae†

1. Coxae with spurs 8
Coxae without spurs 2
2(1). On bats 3
On other hosts 4
3(2). Tarsi 0·13 mm in length ..... *I. simplex simplex*
Tarsi 0·34–0·44 mm in length ..... *I. vespertilionis*
4(2). Palpal article 1 enlarged and extending inwardly to base of mouthparts 5
Palpal article 1 not as above 6
5(4). Cervical grooves well defined, attaining posterior margin of scutum ..... *I. tasmani*
Cervical grooves faint and not attaining posterior margin of scutum ..... *I. hydromyidis*

* The nymphs of *confusus*, *cornuatus*, *hirsti*, and *victoriensis* have not been described.

† The larvae of *confusus*, *cornuatus*, *hirsti*, *antechini*, *fecialis*, *australiensis*, *pterodromae*, and *victoriensis* have not been described.

6(4). Scutum longer than wide and widest anterior to mid-length, (sea birds) ..... *I. uriae*
Scutum wider than long and widest near or posterior to mid-length 7

7(6). Scutum with lateral carinae ..... *I. vestitus*
Scutum without lateral carinae ..... *I. ornithorhynchi*

8(1). Scutum widest well anterior to mid-length (sea birds) 9
Scutum widest near mid-length 11

9(8). Basis capituli with cornua ..... *I. kohlsi*
Basis capituli without cornua 10

10(9). Scutum wider than long ..... *I. eudyptidis*
Scutum longer than wide ..... *I. rothschildi*

11(8). Coxa III with a small spur ..... *I. holocyclus*
Coxa III unarmed ..... *I. trichosuri*

Descriptions of Species

Ixodes eudyptidis Maskell

Ixodes eudyptidis Maskell, 1885, pp. 18–20, pl. viii, figs. 12–14. Neumann, 1899, pp. 128–9; 1904, p. 451 (not var. *signatus*). Nuttall, 1916, pp. 320–7. Ferguson, 1925, p. 29. Fielding, 1926, pp. 37–8, fig. 9. Johnston, 1937, pp. 10–11. Taylor and Murray, 1946, pp. 44–6, figs. 54, 55. Dumbleton, 1953, pp. 11–13, pl. 3, figs. 1–8. Arthur, 1955*a*, p. 18, fig. 1.

Ixodes praecoxalis Neumann, 1899, pp. 121–2.

Ixodes intermedius Neumann, 1899, pp. 132–3.

Ixodes neumanni Nuttall and Warburton, 1911, pp. 217–20, figs. 213, 214. Arthur, 1956*b*, p. 301, fig. 69.

The male of this species is unknown.

Female

Fig. 1, *a–i*

Diagnosis

Scutum longer than wide and widest anteriorly; basis capituli rectangular, the posterior margin elevated, particularly medianly, posterolateral angles rounded and elevated, but no cornua; porose areas occupying most of basis, interval very narrow and elevated; auriculae present; palpi short, the outer margin straight, the inner margin constricted at junction of articles 2 and 3; hypostome dentition 4/4, 3/3, and 2/2; anal grooves mildly constricted posteriorly; all coxae with external spurs, coxa I with broad curved internal spur; trochanters with spurs, reduced and sometimes lacking on trochanter IV; tarsi tapering gradually.

Description

Body.—Semi-engorged, 7·1 by 5·1 mm; engorged, 10·8 by 5·4 mm to 11·2 by 5·9 mm; broadly oval; posterolateral and median grooves well defined; hairs short, pale, scattered.

Capitulum.—0·62–0·74 mm in length; basis dorsally rectangular, 0·50–0·54 mm wide; posterior margin elevated particularly medianly, the posterolateral angles rounded and elevated, but no cornua; posterolateral margins slightly curved; porose areas occupying most of basis, pear-shaped to oval, the longer axis transverse, the interval elevated, greatly reduced; basis ventrally rounded posteriorly,

auriculae well developed and salient; palpi short and broad, 0·55–0·60 mm in length, narrow at base and broadening rapidly to a width about one-third the length, with a broadly rounded apex, outer margin straight, inner margin subparallel with outer margin, indented at junction of articles 2 and 3, article 1 transverse with dorsal anteroposterior ridge, articles 2 and 3 0·46–0·51 mm in length, article 3 about as long as or a little longer than article 2.

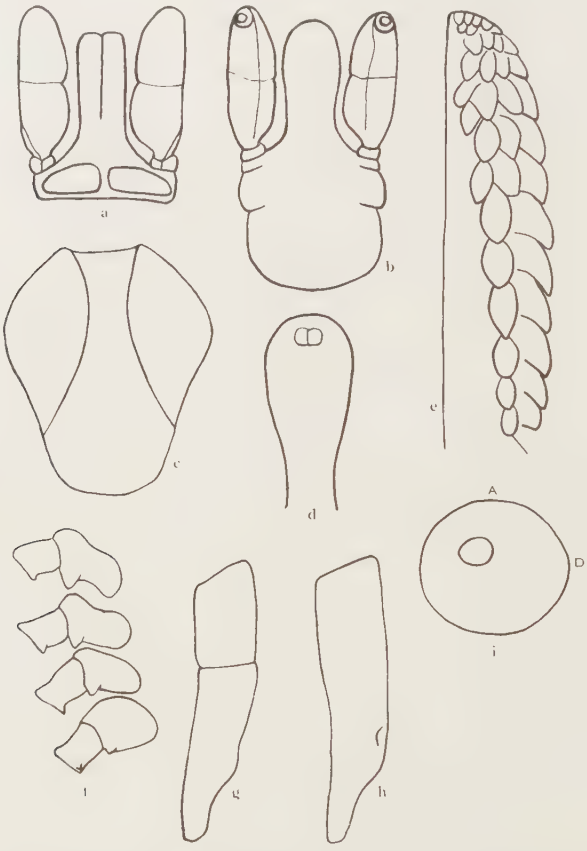

Fig. 1.—*I. eudyptidis*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d* anal grooves; *e*, hypostome; *f*, coxae and trochanters; *g*, tarsus IV; *h*, tarsus I; *i*, spiracular plate.

Hypostome 0·36–0·42 mm in length, apex rounded, clavate, median ventral area unarmed almost to tip; dentition 1–2 rows of 5/5, 4–5 rows of 4/4, 2 rows of 3/3, and 6 rows of 2/2.

Scutum.—Longer than wide, 1·3–1·5 mm by 1·0–1·2 mm and widest a little anterior to mid-length, convex; anterolateral margins convex, posterolateral margins almost straight or a little concave, posterior angle broadly rounded; punctations fine and scattered, some rugae along margins, particularly along anterior and

anterolateral margins; cervical grooves attaining posterolateral margins, moderately deep and convergent anteriorly, becoming shallow and divergent posteriorly; emargination almost lacking; scapulae very shallow, rounded; hairs sparse, most numerous in anterior median and lateral fields.

Genital aperture.—At level of posterior margin of coxa II or in second intercoxal space.

Genital grooves.—Divergent to about level of anus, then gently convergent.

Anal grooves.—Rounded in front and mildly constricted behind.

Spiracular plate.—Broadly oval to subcircular, the longer axis transverse, 0·37–0·43 mm by 0·43–0·46 mm; macula anterior to centre.

Legs.—Slender and of moderate length, joints pale; all coxae with blunt external spurs, largest on coxa I and very small on coxa IV, coxa I with broad, curved, internal spur; trochanters I–III with well-defined ventral, blunt, external spurs, trochanter IV with a very small, more pointed spur or unarmed; tarsi tapering gradually, tarsus I 0·83–0·93 mm in length, tarsus IV, 0·8–0·9 mm in length.

Nymph

Diagnosis

Capitulum as in female, but indentation of inner margin of palpi not conspicuous; hypostome dentition 3/3 and 2/2; scutum as in female; coxae and trochanters as in female; anal grooves mildly constricted behind.

Body.—Semi-engorged, 2·1 by 1·5 mm; engorged, 3·1 by 2·2 mm; widest immediately anterior to spiracular plates; some scattered, minute, pale hairs.

Capitulum.—Length 0·37–0·40 mm; basis dorsally as in female, 0·25–0·27 mm wide; basis ventrally with well-defined auriculae; palpi 0·28–0·31 mm long with maximum width of about 0·09 mm, outer margin straight, indentation on inner margin at junction of articles 2 and 3 not as conspicuous as in female, article 3 about as long as article 2; hypostome broadly rounded apically, dentition 3/3, then 2/2 basally.

Scutum.—0·64 by 0·50 mm to 0·70 by 0·54 mm; shape, cervical grooves, emargination, and scapulae as in female; punctations fine, scattered.

Anal grooves.—As in female.

Spiracular plate.—Oval, the longer axis transverse, 0·13 by 0·10 mm.

Legs.—As in female, tarsus I 0·37–0·40 mm in length, tarsus IV 0·36–0·38 mm in length.

Larva

A description of the larva is given by Dumbleton (1953), the essential features being: basis capituli without cornua; hypostome dentition mainly 3/3 and 2/2; scutum subtriangular, wider than long and widest anterior to mid-length; coxae I–III with external spurs, coxae I–II with slight internal spurs; trochanters without spurs.

Hosts and Distribution

Records of *I. eudyptidis* by Maskell (1885) and Neumann (1899) (*I. eudyptidis*, *I. praecoxalis*, and *I. intermedius*) are from New Zealand. Nuttall and Warburton (1911) (*I. neumanni*) and Dumbleton (1953) also reported it from this country. The hosts given by these workers are *Aestrelata cooki*, *Phalocrocorax* sp., *P. carbo*, *Eudyptes pachyrhynchus*, *Eudyptula minor*, *E. albosignata*, *Pterodroma cooki*, *Chlidonias albistriata*, *Larus novae-hollandiae*, and "wild duck", "penguin", "small sea bird", and "pigeon gull".

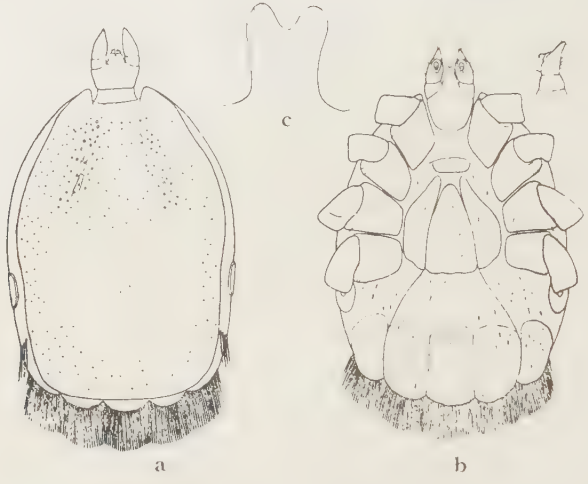

Fig. 2.—*I. uriae*, male (from Cooley and Kohls 1945): *a*, capitulum and body (dorsal view); *b*, capitulum and body (ventral view) with lateral view of palp; *c*, hypostome.

Specimens under this name have also been recorded from Australia by Nuttall (1916), the host being *E. minor* and the localities Tollgates I. and Long Bay, N.S.W., Flinders I., Tas., and Fremantle, W.A. What is considered to be this species was seen by the author (2 ♀♀ and 13 ♂♂) from *E. minor*, Little Green I., Ferneaux Group, Bass Strait, January 1952.

Comments

Nuttall and Warburton (1911) concluded that the description and figures given by Maskell (1885) for *I. eudyptidis* were inadequate, and assigned the tick which Neumann (1899) had described under this name to a new species, *I. neumanni*. Later, however, Nuttall (1916) after an examination of a "cotype" of Maskell's, decided that *I. eudyptidis* was a valid species and degraded *I. neumanni* to synonymy with it. The inclusion of *I. praecoxalis* and *I. intermedius* in the list of synonymy is on the authority of Neumann (1904).

Cooley and Kohls (1945), however, regarded *I. eudyptidis* as a synonym of *I. uriae* as did also Zumpt (1952). Zumpt, furthermore, considered *I. neumanni* a good species. Dumbleton (1953), on the other hand, considered *I. eudyptidis* valid

and published a description of the female, nymph, and larva. Dumbleton's determinations of *I. eudyptidis* has been supported by Arthur (1955*a*), but Arthur (1956*b*) agreed with Zumpt (1952) that *I. neumanni* is distinct.

The present author considers that as Nuttall (1916) is the only worker who has examined both Maskell's *I. eudyptidis* and Nuttall and Warburton's *I. neumanni*, his statement that the two are synonymous should be accepted.

The Australian ticks from *E. minor*, from Little Green I., were considered identical with material from *Pareora gorge*, New Zealand, identified as *I. eudyptidis* by Mr. L. J. Dumbleton. There are, however, some minor differences. Capitular and scutal measurements are larger, the spurs on the coxae and trochanters appear more rounded, and the apical region of tarsi I and IV is not as slender as in the New Zealand specimens.

I. eudyptidis is close to *I. kohlsi* and the differences between the two species are discussed under *I. kohlsi*.

Ixodes uriae White

Ixodes uriae White, 1852, p. 210. Cooley and Kohls, 1945, pp. 223–6, figs. 86, 87. Dumbleton, 1953, pp. 14–15, pl. 2, figs. 13, 14.

Hyalomma puta, Pickard-Cambridge, 1878, p. 222, pl. xiii, fig. 4.

Ixodes borealis Kramer and Neuman, 1883, p. 518.

Ixodes fibriatus Kramer and Neuman, 1883, p. 518.

Ixodes putus Neumann, 1899, pp. 125–7, figs. 7–9. Nuttall and Warburton, 1911, pp. 256–61, figs. 254–60. Nuttall, 1912, p. 60, fig. 9. Ferguson, 1925, p. 28. Fielding, 1926, pp. 35–7, fig. 8. Johnston, 1937, pp. 7–10. Taylor and Murray, 1946, pp. 60–3, figs. 63–9.

Ixodes (*Ceratixodes*) *putus* Pomerantzev. Anastos, 1950, pp. 57–8.

Ceratixodes putus Neumann, 1902, pp. 117–18, fig. 4. Wheler, 1906, pp. 415–16, figs. 25, 26.

Ceratixodes uriae Oudemans, 1936, p. 796. Schulze, 1938, pp. 12–17. Zumpt, 1952, pp. 12–15. Arthur, 1953, pp. 161–72; 1956*b*, pp. 278–80, figs. 27–29.

Male

Fig. 2, *a–c*

Diagnosis

A medium-sized tick readily recognized by the upturned, pointed palpi and the posterior fringe of 5 tufts of hair; hypostome rudimentary, denticles faintly indicated, 1/1; ventral plates prominent, an additional plate each side of median plate; coxae unarmed; tarsi tapering gradually.

Description

Body.—Length 3·2–3·4 mm, wider behind than in front, the lateral borders parallel for posterior two-thirds; marginal body fold narrow; posteriorly with 5 ridges or lobes bearing tufts of long, strong hairs (really attached to ventral plates), and a small tuft of similar hairs arising from marginal fold on each side and anterior to the large, lateral, posterior tuft; otherwise hairs short, pale, and scattered.

Capitulum.—Short, about 0·63–0·66 mm in length; basis dorsally 0·54 mm wide, posterior margin straight, no cornua, posterolateral margins straight and a little divergent anteriorly, basis ventrally rounded posteriorly, no auriculae; palpi much longer than mouthparts, article 1 rounded and conspicuous, articles 2 and 3 indistinctly separated, curving convergently and pointed distally, article 4 (ventrally) arising far back from apex of article 3, with some small hairs.

Hypostome rudimentary, much shorter than palpi, 0·16 mm in length, broad, bilobed, with faint indications of 6 teeth arranged 1/1.

Scutum.—Broadly oval, 2·9–3·0 mm by 2·0–2·2 mm, surface convex, posterolateral margins a little concave, posterior margin somewhat flattened; punctations numerous, relatively fine, unequal; cervical grooves distinct, diverging posteriorly to reach a large shallow depression on either side; emargination deep; scapulae bluntly pointed.

Genital aperture.—In first intercoxal space.

Ventral plates.—Pregenital plate wider than long, semilunar; median plate somewhat triangular terminating opposite coxa IV, widest at base and a little more than twice as long as broad, with a slightly longer contiguous plate on each side, pointed anteriorly and convex externally; anal plate rectangular, rounded posteriorly, does not include anus; adanal plates somewhat rectangular, the anterior and posterior margins convex; epimeral plates somewhat smaller; margins of anal, adanal, and epimeral plates extending posteriorly and furnished with long, bristle-like hairs; median and its accompanying lateral plates faintly punctate; anal, adanal, and epimeral plates with distinct punctations.

Spiracular plate.—Suboval, the longer axis transverse.

Legs.—Relatively stout, length moderate; coxae contiguous, surface faintly punctate, unarmed; trochanters unarmed; tarsi tapering gradually.

Female

Fig. 3, *a–h*

Diagnosis

Body with numerous hairs dorsally and ventrally; capitulum relatively small, palpi wide apart, curving towards mouthparts, widest distally and clavate; hypostome dentition 2/2; scutum widest near anterior end, with numerous punctations, emargination shallow; coxae unarmed, tarsi terminating somewhat abruptly.

Description

Body.—Unfed specimens 4·1 by 3·0 mm, engorged specimens 11·8 by 7·2 mm; oval, spiracular plates visible from above; dorsally and ventrally with numerous long hairs, which may be absent or scarce in the anterior, median ventral region and from an area posterior to anus.

Capitulum.—Length 0·6–0·7 mm; basis dorsally 0·54–0·60 mm wide, posterior margin a little convex, posterolateral angles rounded, no cornua, posterolateral margins divergent anteriorly; porose areas well defined, large, broadly oval, the longer axis transverse, interval narrow; basis ventrally rounded posteriorly, no

auriculae; palpi set far apart, curving towards mouthparts, article 1 large, rounded, articles 2 and 3 indistinctly separated, widest distally giving palpi a clavate appearance, article 4 often prominent from above.

Hypostome about 0·40–0·42 mm in length, sides subparallel, apex rounded, dentition 2/2 of strong, almost equal, mildly pointed teeth.

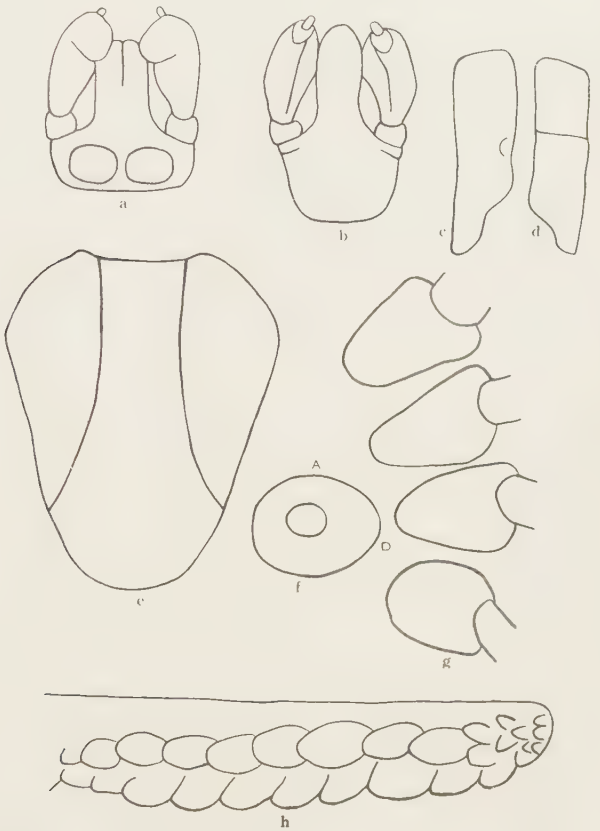

Fig. 3.—*I. uriae*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, tarsus I; *d*, tarsus IV; *e*, scutum; *f*, spiracular plate; *g*, coxae; *h*, hypostome.

Scutum.—Longer than wide, 1·4–1·7 mm by 1·1–1·2 mm, widest near anterior end, glossy, convex between cervical grooves; posterolateral margins slightly sinuous or convex, posterior angle rounded; punctations numerous, unequal, fairly evenly distributed, frequently confluent in places laterally; cervical grooves well defined, broad and divergent posteriorly to attain the posterolateral margins; emargination shallow; scapulae short, rounded.

Genital aperture.—In second intercoxal space.

Genital grooves.—Subparallel for about half the length, then divergent.

Anal grooves.—Divergent posteriorly.

Spiracular plate.—Suboval, the longer axis transverse, 0·48 by 0·41 mm.

Legs.—Length moderate; coxae unarmed, coxae I–III somewhat triangular, coxa IV rounded; tarsi with subterminal humps, tarsus I 0·79–1·07 mm in length, tarsus IV 0·86–1·1 mm in length.

Nymph

Fig. 4, *a–g*

Diagnosis

Palpi and shape of scutum as in female; hypostome dentition 2/2; coxae and anal grooves as in female.

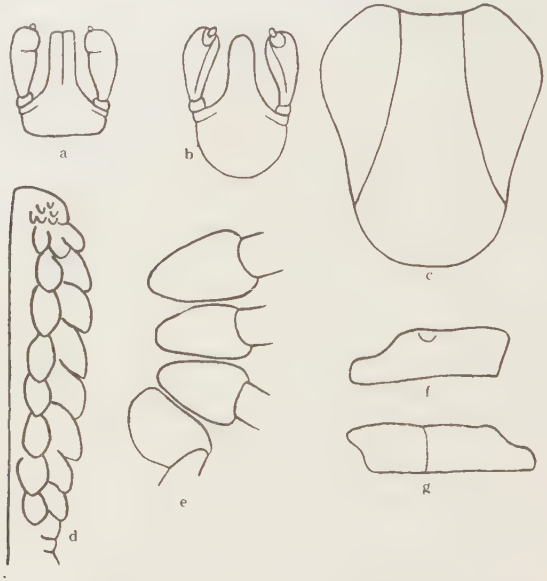

Fig. 4.—*I. uriae*, nymph: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, hypostome; *e*, coxae; *f*, tarsus I; *g*, tarsus IV.

Description

Body.—Unfed specimens 1·1 by 1·0 mm, widest in region of spiracles which are situated towards the posterior end; some scattered pale hairs on dorsum, most numerous laterally; engorged specimens up to 3·4 by 2·1 mm, oval.

Capitulum.—Length about 0·36 mm; basis dorsally 0·32 mm wide, as in female, palpal article 1 conspicuous, about 0·07 mm in length, articles 2 and 3 about 0·2 mm in length, appearance of palpi much as in female, except that increase in width distally more gradual than in female.

Hypostome about 0·22 mm in length, sides parallel, apex rounded; dentition 2/2 of about 9–10 strong teeth.

Scutum.—Shape as in female, 0·80–0·85 mm by 0·60–0·71 mm; punctations mainly fine, evenly distributed; cervical grooves well defined, reaching postero-lateral margins, emargination very shallow.

Spiracular plate.—Suboval, the longer axis transverse, 0·35 by 0·27 mm.

Anal grooves.—Ill-defined, divergent posteriorly.

Legs.—As in female; tarsus I 0·43 mm in length; tarsus IV 0·40 mm in length.

Larva

Diagnosis

Scutum as in female; palpi as in female; dentition 2/2, coxae unarmed.

Description

Body.—Engorged specimens broadly oval, 2·14 by 1·60 mm, hairs few, short.

Capitulum.—Length 0·21 mm; basis dorsally rectangular, 0·20 mm wide; basis ventrally with surface convex, posterior margin rounded; palpi in appearance as in female, about 0·17 mm in length, article 4 prominent dorsally.

Hypostome broad, rounded apically; dentition 2/2 of 6–8 teeth.

Scutum.—Shape as in female, 0·44–0·50 mm by 0·32–0·37 mm, surface finely granulated, median fields convex; cervical grooves well defined and extending to posterolateral margin.

Anal grooves.—Faint, divergent posteriorly.

Legs.—Coxae unarmed; tarsi tapering gradually, tarsus I about 0·28 mm in length, tarsus IV about 0·31 mm in length.

Hosts and Distribution

I. uriae is a widely distributed parasite of sea birds in both Northern and Southern Hemispheres. Neumann (1911) recorded it from King I. and suggested this locality as being in British Columbia. The record probably refers to King I., Bass Strait, Tas. (Nuttall and Warburton 1911), and specimens from this locality have been seen by the present author. The species is common in the Antarctic (Johnston 1937; Dumbleton 1953).

The specimens seen in this revision were from various sea birds on Macquarie and Heard Is., and from "Tasmanian penguin", King I., 12.ix.27, 1 ♀, 1 ♂, and from "nests of wandering albatross", Five Islands Group, N.S.W., 6 ♀♀.

Comments

The validity of the name *I. uriae* for this species is discussed by Cooley and Kohls (1945). These workers and also Zumpt (1952) considered *I. eudyptidis* a synonym of *I. uriae*, but this opinion is not shared by either Dumbleton (1953) or Arthur (1955*a*), both of whom considered it a good species.

Ixodes kohlsi Arthur

Ixodes percavatus Tubb, 1937, pp. 416–18 (not *I. percavatus* Neumann, 1906); ? 1938, pp. 346 (not seen).

Ixodes kohlsi Arthur, 1955*a*, pp. 18–21, pl. 1, figs. 2–14, pl. 4, figs. 15–21. Mykytowycz and Hesterman, 1957, p. 165.

Male

Fig. 5, *a–i*

Diagnosis

A dark, medium-sized, oval tick with a prominent, raised, marginal body fold; scutum with fine punctations; capitulum short, basis with posterior margin elevated, no cornua, and followed by an elongate "neck"; palpal articles 2 and 3 inclined ventrad; hypostome conspicuously indented apically with outer margins serrated and 2–3 teeth distally; anal plate elongate and constricted posteriorly; coxae with terminal rounded ridge; tarsi curved ventrad distally.

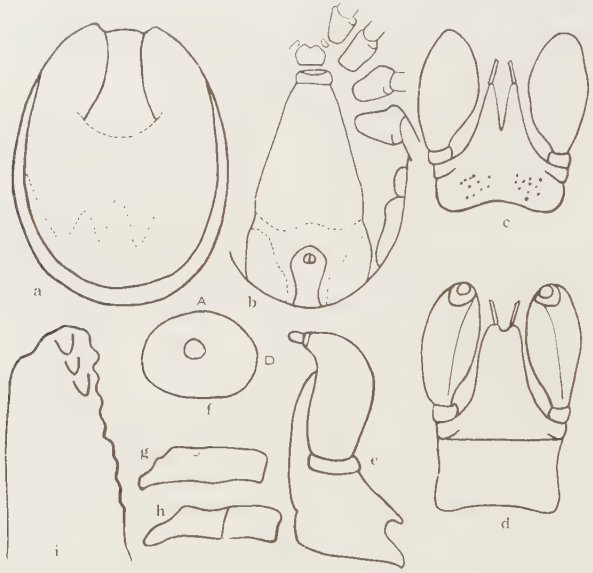

Fig. 5.—*I. kohlsi*, male: *a*, body (dorsal view); *b*, body (ventral view); *c*, capitulum (dorsal view); *d*, capitulum (ventral view); *e*, palp (lateral view); *f*, spiracular plate; *g*, tarsus I; *h*, tarsus IV; *i*, hypostome.

Description

Body.—Oval, dark, 3·5–3·8 mm by 2·6–3·2 mm; marginal body fold wide and conspicuous in the flat, older specimens, ill defined or absent in the thick-bodied newly emerged specimens; numerous short, stiff hairs.

Capitulum.—Length 0·53–0·57 mm; resting on an unusually elongate and parallel-sided "neck", basis dorsally 0·43 mm wide, with 2 groups of punctations, posterolateral margins straight and slightly divergent anteriorly, posterior margin elevated and concave, with broadly rounded posterolateral angle, but without cornua; basis ventrally with posterior margin a little concave, the lateral margins straight, palpiger bearing article 1 projecting a little laterally; palpi short and broad with numerous bristles and a row of median bristles ventrally on articles 2 and 3, article 1 rounded, wider than long, articles 2 and 3 indistinctly separated, 0·31–0·34 mm

long, narrow at base, and widening at mid-length to a maximum width of 0·18 mm, curving ventrad apically with article 4 directed anteroventrally.

Hypostome 0·25 mm long, broad at base and narrowing apically where it becomes strongly indented; dentition reduced to serrations on the outer margins and to 2–3 small teeth apically.

Scutum.—Oval, 3·1–3·4 mm by 1·7–2·3 mm, convex, glossy, with depressed areas laterally and in median third; pseudoscutum faintly visible; punctations fine, more numerous laterally and posteriorly; cervical grooves well defined, attaining, or almost so, the posterior margin of pseudoscutum; no lateral carinae; emargination moderate; scapulae rounded; hairs few and short; degree of sclerotization variable as shown in Figure 5*a*, and in plate II, figures 16–18, of Arthur (1955*a*).

Genital aperture.—In second intercoxal space or at level of posterior margin of coxa II.

Ventral plates.—Pregenital plate hexagonal with a small notch anteriorly and with a small oval or crescent-shaped plate on either side anteriorly; other plates irregularly sclerotized (this may be because the males examined were newly emerged and may not have hardened), as in Figure 5*b*, and also plate II, figure 19, *A–C*, of Arthur (1955*a*), the margins of the median and adanal plates ill defined; anal plate rounded in front, constricted behind; numerous, short, pale hairs.

Spiracular plate.—Broadly oval, the longer axis transverse, 0·28 by 0·33 mm.

Legs.—Strong and well furnished with relatively long, pale bristles; coxae convex, glossy, unarmed, with shallow rounded ridges distally; tarsi slender, narrowing somewhat abruptly apically, the apices directed ventrad; tarsus I 0·62–0·65 mm in length, tarsus IV, 0·72–0·80 mm in length.

Female

Fig. 6, *a–i*

Diagnosis

Thickly clothed with hairs (unfed specimens), scutum widest anteriorly; capitulum with posterior margin of basis elevated, and with shallow, rounded cornua, porose areas large, auriculae present; palpi short; hypostome mainly 3/3, becoming 2/2 basally with the median ventral area almost completely unarmed; anal grooves constricted behind; all coxae with external spur; coxa I also with broad internal spur; all trochanters with external spur; tarsi tapering rather abruptly.

Description

Body.—Unfed specimens 2·5–2·8 mm by 1·8–2·1 mm, broadly oval and widest just behind coxa IV, with numerous, pale, decumbent hairs and with 4 festoon-like structures posteriorly due to extension dorsally of anal and genital grooves; engorged specimens 8·2–9·6 mm by 4·5–5·2 mm, posterolateral grooves elongate, median groove short; hairs scattered.

Capitulum.—Length 0·73–0·78 mm; basis dorsally convex, 0·57–0·63 mm wide, posterior margin elevated, particularly medianly, with broad, shallow, rounded

cornua, posterolateral margins divergent anteriorly and curved; porose areas transversely oval, depressed, large, the interval narrow; basis ventrally with the posterior margin convex, strongly constricted behind the auriculae, which are large, rounded, and directed posterolaterally; palpi short and broad, rounded apically, article 1 rounded about as long as broad, articles 2 and 3 with suture indistinct but apparent,

Fig. 6.—*I. kohlsi*, female: *a*, scutum; *b*, coxae and trochanters; *c*, hypostome; *d*, capitulum (dorsal view); *e*, capitulum (ventral view); *f*, tarsus I; *g*, tarsus IV; *h*, spiracular plate; *i*, anal grooves.

0·43–0·48 mm long, constricted at base and broadening rapidly to attain a maximum width of a little more than one-third the length, article 3 0·16–0·20 mm long with some long bristles apically.

Hypostome about 0·43–0·51 mm long, the apex rounded, the sides subparallel, a ventral median unarmed area extending for practically the entire length; dentition 1 row of 6/6, 1–2 rows of 5/5, 1–2 rows of 4/4, 5–6 rows of 3/3, and 6 rows of 2/2.

Scutum.—Suboval, 1·2–1·6 mm by 0·9–1·1 mm, longer than wide and widest anteriorly, median fields convex, anterolateral margins convex, posterolateral margins slightly sinuous, posterior angle broadly rounded; punctations fine medianly, rugose laterally; cervical grooves deep, short, and converging anteriorly, continuing posteriorly as broad, divergent, shallow depressions to attain the posterior margin; no lateral carinae; emargination almost obsolete, scapulae very shallow, rounded; hairs few and mainly towards anterior and anterolateral margins.

Genital aperture.—Usually in the second intercoxal space, but sometimes level with the posterior margin of coxa II.

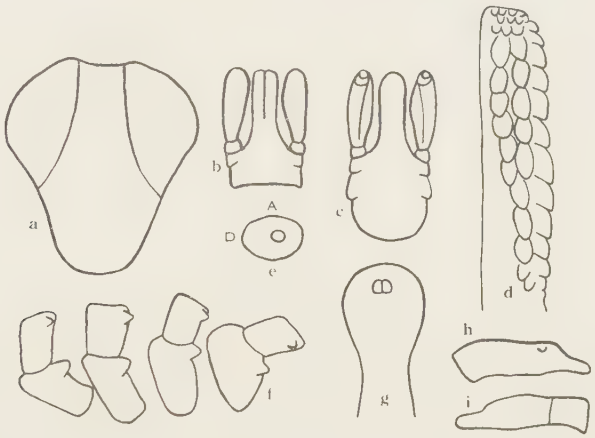

Fig. 7.—*I. kohlsi*, nymph: *a*, scutum; *b*, capitulum (dorsal view); *c*, capitulum (ventral view); *d*, hypostome; *e*, spiracular plate; *f*, coxae and trochanters; *g*, anal grooves; *h*, tarsus I; *i*, tarsus IV.

Anal grooves.—Rounded in front and in unfed and little fed specimens strongly constricted behind, but in engorged specimens the constriction less prominent.

Spiracular plate.—Broadly oval, the longer axis transverse, 0·24–0·30 mm by 0·30–0·36 mm.

Legs.—Strong and dark with pale articulations; coxae convex, smooth, coxa I with a broad, rounded, shallow internal salience, coxae II and III frequently also shallowly salient internally, all coxae with well-developed external spurs, that on coxa I being the largest and most acute; all trochanters with a well-defined external spur, strongest on trochanters II and III and sometimes much reduced on trochanter IV; tarsi ending somewhat abruptly, tarsus I 0·66–0·80 mm long, tarsus IV 0·70–0·86 mm long.

Nymph

Fig. 7, *a–i*

Diagnosis

Scutum and capitulum as in the female; hypostome mainly 3/3, becoming 4/4 apically, and 2/2 basally; coxae, trochanters, and anal grooves as in the female.

Description

Body.—Oval, broadly so in unfed specimens, unfed nymph 1·27 by 1·03 mm, engorged nymph to 3·9 by 3·0 mm; many decumbent, pale hairs.

Capitulum.—Length about 0·38 mm; basis dorsally about 0·28 mm wide, somewhat rectangular, the posterior margin elevated with shallow, raised cornua; basis ventrally rounded posteriorly, auriculae present as small, salient lobes; palpi as in female.

Hypostome about 0·24 mm long, dentition 5/5 and 4/4 distally of small teeth, then 5–6 rows of 3/3, and 5 rows of 2/2.

Scutum.—Shape and cervical grooves as in female, 0·61–0·64 mm by 0·49–0·50 mm; glossy; punctations few and fine; some pale hairs.

Anal grooves.—As in female.

Spiracular plate.—Broadly oval, the longer axis transverse, 0·11–0·13 mm by 0·15–0·17 mm.

Legs.—Coxae and trochanters with spurs as in female; tarsi tapering somewhat abruptly, tarsus I 0·35 mm in length, tarsus IV 0·38 mm in length.

Larva

Fig. 8, *a–g*

Diagnosis

Shape of scutum as in female; capitulum with rectangular basis, the posterior margin elevated, with shallow cornua; hypostome dentition mainly 3/3, basally 2/2; coxae and trochanters with spurs as in female; tarsi tapering somewhat abruptly.

Description

Body.—Oval, broadly so in unfed larvae; unfed larvae 0·60 by 0·51 mm, engorged larvae 1·74 by 1·21 mm.

Capitulum.—Length about 0·21 mm; basis dorsally rectangular, 0·14 mm wide, posterior margin straight, elevated, with shallow raised cornua; basis ventrally rounded posteriorly, no apparent auriculae; palpi slender, articles 2 and 3 with no distinct suture, 0·14 mm long, narrow at base, rounded apically.

Hypostome rounded apically, dentition mainly 3/3, 2/2 basally and 4/4 distally, about 10 large teeth in outer and middle files.

Scutum.—Shape as in female, 0·32 by 0·22 mm, some pale hairs.

Anal grooves.—Indistinct, but appear subparallel posteriorly.

Legs.—Coxae and trochanters as in female; tarsi tapering somewhat abruptly; tarsus I 0·17–0·20 mm in length, tarsus IV 0·18–0·20 mm in length.

Hosts and Distribution

This species seems to be the common tick on the little penguin, *Eudyptula minor*, on Australian shores. The specimens examined by Arthur (1955*a*), and from which he described the species, were taken from this host or from its nests at Robe,

S. Aust., and on Lady Julia Percy I., Vic. It has also been recorded from *E. minor* on Montagu I., N.S.W., by Mykytowycz and Hesterman (1957).

Material examined.—NEW SOUTH WALES: under stones, Five Islands Group, 13.iii.1936, 5 ♀♀; *E. minor*, Five Islands Group, 7.iii.1959, 7 ♀♀; *E. minor*, Five Islands Group, 7.xi.1959, 3 ♀♀; *E. minor*, Five Islands Group, 12.xi.1955, 1 ♀; *E. minor*, Tollgates I., 10.xi.1959, 2 ♀♀; man (attached), Tollgates I., 25.xi.1959, 1 ♂; crawling on tent, Tollgate I., 6 ♂♂; *E. minor*, Tollgates I., 2 ♀♀. VICTORIA: *E. minor* (on body and in nest), Lady Julia Percy I., February 1937, 2 ♂♂, 6 ♀♀, 18 ♂♂; Lady Julia Percy I., 1 ♂, 2 ♀♀, numerous bred larvae; "fairy penguin", Phillip I., 15.ii.1959, 5 ♀♀; *E. minor*, Williamstown, 2.vii.1948, 5 ♂♂. SOUTH AUSTRALIA: locality and date illegible, 8 ♀♀; "penguin", Greenly I., 7–16.xii.1947, 3 ♀♀; *Phalacrocorax fuscescens*, 1 ♀. TASMANIA: *E. minor*, Kingston Beach, 10.x.1951, 1 ♂, 1 ♀, 5 larvae; "penguin", North Bruny I., 8.iii.1940, 6 ♀♀.

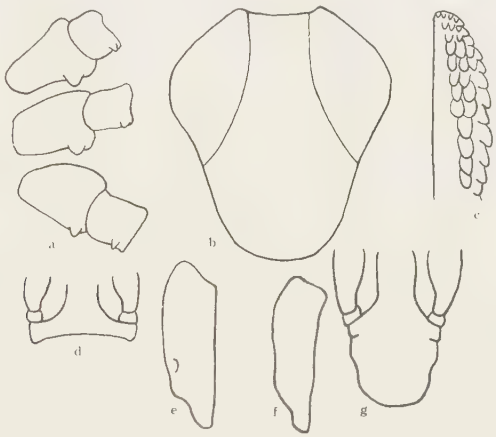

Fig. 8.—*I. kohlsi*, larva: *a*, coxae and trochanters; *b*, scutum; *c*, hypostome; *d*, basis capituli (dorsal view); *e*, tarsus I; *f*, tarsus IV; *g*, basis capituli (ventral view).

The above specimens from Lady Julia Percy I. and also Arthur's specimens from this locality were collected by Tubb (1937) who identified them as *I. percavatus*. Tubb in his description mentioned that specimens were also taken from the nests of the mutton-bird, *Puffinus tenuirostris*, "but only where the penguin nesting ground overlapped that of the mutton-bird." He found that young and moulting penguins often carried adults, nymphs, and larvae, but only nymphs and larvae occurred on fully fledged birds. What was probably *I. kohlsi* was also recorded by Tubb (1938) from *E. minor*, Langton I., S. Aust.

According to Mykytowycz and Hesterman (1957), this tick occurs mainly on the head of its host, where it cannot be removed by preening.

Comments

Arthur (1955*a*) in describing *I. kohlsi* gave detailed descriptions of the male and nymph, but was content to compare the female with *I. rothschildi* and to list the differences between them. These differences are in the dentition and its distribution, the shape of the anal grooves, the position of the genital aperture, the shape of the tarsi, and in the structure of Haller's organ.

The specimens seen by the author from *E. minor*, Lady Julia Percy I., J. A. Tubb, are undoubtedly portion of the material examined by Arthur (1955*a*) and from which he selected his types. The males and nymphs agreed very closely with the descriptions given by Arthur (1955*a*). There are, however, some differences in the descriptions of the female given by the author and that published by Arthur (1955*a*) and based on his description of *I. rothschildi* (Arthur 1953). These differences lie mainly in the degree of development of the emargination of the scutum, the absence of lateral carinae, and in the armature of the coxae.

I. kohlsi is very close to *I. eudyptidis*, but the female of the latter species may be readily distinguished by the absence of cornua, by the more strongly elevated posterior margin of the basis capituli, by the usually conspicuous indentation at the inner junction of palpal articles 2 and 3, by the more pointed internal spur on coxa I, by the milder constriction in the anal grooves, and by the dentition.

Ixodes rothschildi Nuttall & Warburton

Ixodes percavatus var. *rothschildi* Nuttall and Warburton, 1911, p. 221.
Ixodes rothschildi Arthur, 1953, pp. 222–6, figs. 1–12; 1955*b*, pp. 711–12; 1956*b*, p. 281; 1958, pp. 124–9, figs. 1–7 (not *I. rothschildi* Zumpt, 1952, p. 13).

This species was originally described by Nuttall and Warburton (1911) as a variety of *I. percavatus* but Zumpt (1952) raised it to specific rank. Arthur (1953), working independently, arrived at the same conclusion and gave a detailed description of the female and nymph, and later described the larva and male (Arthur 1955*b*, 1958). Arthur (1958), however, considered that the species to which Zumpt (1952) applied the name *I. rothschildi* was not the same species determined by him under this name; Zumpt's species was regarded as new and was designated *I. diomediae*.

There is a single record of *I. rothschildi* from Australia, when Arthur (1953) referred to this species two females collected by Cleland from the little penguin, *Eudyptula minor*, from Perth, W.A. However, this record must be regarded as doubtful for later Arthur (1958), in discussing the distribution of this tick noted that "apart from the type species for which no locality data are available, the existing records are all from islands off the British coast."

Ixodes pterodromae Arthur

Ixodes pterodromae Arthur, 1960, pp. 217-23, figs. 55-62b.

The male and larva are unknown.

Female

Fig. 9, *a–i*

Diagnosis

Scutum suboval, emargination very shallow; basis capituli with large, rounded, raised, and posterolaterally directed cornua, porose areas large, covering most of basis, auriculae strong; palpi clavate, article 1 large with a conspicuous, internal, anteriorly directed horn-like process and a distinct mesodorsal spur; hypostome

dentition mainly 4/4, becoming 3/3 and 2/2 basally; anal grooves wide open posteriorly; coxae I–III with internal spurs, those on coxae II and III small, pointed, all coxae with external spurs; trochanters with strong dorsal and ventral spurs.

Description

Body.—Unfed specimens 2·3 by 1·5 mm, engorged specimens to 10·8 by 8·2 mm; marginal groove well defined, disappearing on engorgement; with scattered, short, pale hairs.

Fig. 9.—*I. pterodromae*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, hypostome; *d*, scutum; *e*, coxae and trochanters; *f*, tarsus I; *g*, tarsus IV; *h*, anal grooves; *i*, spiracular plate.

Capitulum.—Length 0·58–0·64 mm; basis dorsally 0·46–0·58 mm wide, posterior margin almost straight, slightly elevated, posterolateral margins curved; cornua prominent, dark, rounded, and somewhat elevated, slightly longer than their greatest width, directed posterolaterally; porose areas large, subcircular or broadly oval, almost contiguous with posterior margin and extending towards base of palpi, the interval narrow and depressed; basis ventrally rounded posteriorly, auriculae strong, as large, heavy spurs with almost straight lateral margins; palpal article 1

large with a prominent, internal, anteriorly directed, horn-like process, directed dorsally apically, and with a distinct mesodorsal spur, articles 2 and 3 with faint sutural line, clavate, about 0·30–0·35 mm in length.

Hypostome spatulate and broadly rounded apically, dentition with minute teeth apically, mainly 4/4 and 3/3, becoming 2/2 and sometimes also 1/1 basally.

Scutum.—Suboval, longer than wide, 1·10–1·32 mm by 0·86–1·01 mm, widest just anterior to mid-length, median field convex, lateral fields flat, anterolateral margins straight or slightly sinuous, posterolateral margins convex, posterior angle broadly rounded; no lateral carinae; punctations mainly fine, moderate in number and scattered, a few relatively coarse and shallow with some confluency sometimes most numerous near the margins; cervical grooves broad becoming shallow and divergent posteriorly, but not quite attaining the posterolateral margins; emargination almost lacking; scapulae shallow and rounded.

Genital aperture.—At level of coxa III.

Genital grooves.—Divergent and practically straight.

Anal grooves.—Broadly rounded anteriorly, slightly convergent posteriorly.

Spiracular plate.—Subcircular or broadly oval, the longer axis transverse, about 0·31–0·36 mm in length; macula anterior and a little dorsal to centre.

Legs.—Relatively strong and of moderate length; coxae convex, smooth, with some long hairs, coxa I with a broad, blunt internal spur, internal spurs on coxae II and III small, pointed, all coxae with prominent external spurs, that on coxa I relatively large and heavy; trochanters with strong ventral and dorsal spurs; tarsi slender, tapering gradually, tarsus I 0·72–0·80 mm in length, tarsus IV 0·68–0·78 mm in length.

Nymph

Diagnosis

As in female, cornua strong and elevated.

Description

Body.—Partly engorged and engorged specimens 2·7–3·2 mm by 1·9–2·4 mm; some small, pale, scattered hairs.

Capitulum.—Length 0·30–0·35 mm; basis dorsally 0·25–0·28 mm wide, shape as in female, surface smooth, but occasionally with some scattered punctations in region of porose areas, cornua strong and divergent; basis ventrally rounded posteriorly, auriculae prominent; palpi as in female, articles 2 and 3 about 0·19 mm in length.

Hypostome about 0·21 mm in length, broadly rounded apically, some minute teeth apically, dentition mainly 3/3 becoming 2/2 basally.

Scutum.—Longer than wide, suboval, 0·60 by 0·50 mm, and widest just anterior to midlength; punctations mainly laterally where they tend to show some confluency; cervical grooves, emargination, and scapulae as in female.

Anal grooves.—As in female.

Spiracular plate.—Broadly oval to subcircular, about 0·24 mm along greater axis.

Legs.—As in female.

Hosts and Distribution

The Australian record is based on 2 ♀♀ and 5 ♂♂ from *Diomedea exulans*, De Witt I., Tas., 10.viii.1916. 8 ♀♀ and 7 ♂♂ from "penguin", Macquarie I., were also available.

The species was described by Arthur (1960) from females from *Pterodroma brevirostris* and *P. mollis*, Marion I., Indian Ocean.

Comments

Considerable confusion has existed in the determination of the species *I. auritulus* Neumann, 1904, and *I. percavatus* Neumann, 1906. Zumpt (1952), from an examination of females and nymphs from the type locality, concluded that *I. percavatus* was identical with *I. auritulus*, and Arthur (1953), from a comparison of the types of both species, supported Zumpt's decision. Later, however, Arthur (1960), from a further study of the types and of other material, concluded that there existed a *percavatus* group with a well-defined mesodorsal spur on palpal article 1, and an *auritulus* group in which this palpal spur was absent. Four species were placed in the former group, namely *I. percavatus* and three new species, *I. cornuae*, *I. zumpti*, and *I. pterodromae*. These four species are very similar but have been distinguished by Arthur (1960) mainly on the form of the porose areas, cornua, and coxal armature.

The female specimens described as *I. pterodromae* by the present author were originally identified as *I. auritulus*. When Arthur's paper (1960) appeared they were submitted to him for identification and were determined as *I. pterodromae*. The specimens agree substantially with his description of this species. A description of the nymph is published for the first time.

Ixodes simplex simplex Neumann

Ixodes simplex Neumann, 1906, pp. 197–8. Nuttall and Warburton, 1911, pp. 207–8. Bedford, 1934, p. 89, fig. 36.

Ixodes simplex simplex Arthur, 1956*a*, pp. 186–93, figs. 24–31, 33–38, 40–43. Hoogstraal, 1956, pp. 563–6, pl. lxvi, figs. 230, 231. Anon, 1957, pp. 23–4, pl. 37.

The male of this species is unknown.

Female

Fig. 10, *a–h*

Diagnosis

Palpi short, clavate; porose areas depressed with large scattered pits; hypostome dentition 3/3 and 2/2; scutum longer than broad with sparse, fine punctations; legs moderate in length, coxae unarmed, tarsi slender; found on bats.

Description

Body.—Partly engorged specimens, broadly oval, 4·4–4·6 mm by 4·3–4·5 mm; hairs relatively long, dense dorsally, particularly laterally, sparse ventrally; posterolateral and median grooves not well defined.

Capitulum.—Length 0·5 mm; basis dorsally 0·38 mm wide, posterior margin a little sinuous, elevated medianly, no cornua, posterolateral margins slightly curved; basis ventrally with a slightly rounded posterior margin and with triangular ridges just posterior to basal article of palpi; porose areas large, subcircular, depressed, the pits relatively large, and scattered, the interval very narrow; palpi short, 0·33 mm in length and with a maximum width of 0·12 mm, clavate, the external margin straight, suture between articles 2 and 3 indistinct, article 2 0·16 mm long, article 3 0·14 mm long.

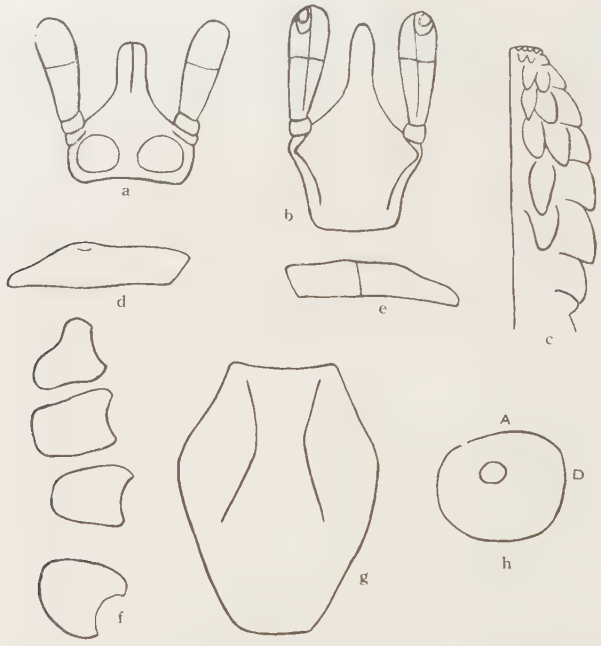

Fig. 10.—*I. simplex simplex*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, hypostome; *d*, tarsus I; *e*, tarsus IV; *f*, coxae; *g*, scutum; *h*, spiracular plate.

Hypostome bluntly pointed, 0·18 mm in length, dentition with 1 row of 4/4, 4 rows of 3/3 distally, the apical rows minute, then 2 rows of 2/2 and 1 row of 1/1.

Scutum.—Longer than wide, 1·12–1·14 mm by 0·79–0·83 mm, widest slightly anterior to mid-length and narrowing appreciably posteriorly, depressed adjacent to lateral angles; anterolateral margins concave, posterolateral margins straight or slightly convex; punctations fine, sparse, scattered, the depressed areas near lateral angles wrinkled; emargination almost obsolete; scapulae rounded, small; some hairs present mainly in anterior and anterolateral fields.

Genital aperture.—At level of coxa III.

Anal grooves.—Relatively narrowly rounded anteriorly, markedly divergent posteriorly.

Spiracular plate.—Subcircular or broadly oval, the longer axis transverse, the anterior margin somewhat flattened, 0·24 by 0·27 mm.

Legs.—Moderate in length; coxae unarmed; tarsi slender, tapering gradually, tarsus I 0·73 mm in length, tarsus IV 0·74 mm in length.

Nymph

Diagnosis

As for the female.

Description

Body.—Measurements 2·3–2·6 mm by 1·8–2·3 mm, with scattered, pale hairs.

Capitulum.—Length 0·30–0·32 mm; basis dorsally 0·26 mm wide, posterior margin straight or slightly convex, posterolateral angles rounded, no cornua, posterolateral margins slightly curved; basis ventrally with a mild waist, no auriculae, posterior margin somewhat rounded; palpi nearly straight externally, curved internally, article 1 rounded and narrow, articles 2 and 3 with indistinct suture, narrow at base and gradually widening distally, about 0·18 mm long, article 3 about 0·09 mm long.

Hypostome broad basally, curving gently to a blunt point apically, length about 0·12 mm; denticles indistinct but apparently 1 row of 4/4, 3 rows of 3/3, 3 rows of 2/2, and 1 row of 1/1.

Scutum.—Longer than wide, 0·53–0·61 mm by 0·46–0·52 mm, and widest just anterior to mid-length; glossy; lateral fields depressed and with rugae, punctations otherwise fine and uniformly distributed; cervical grooves distinct, more obvious posteriorly where they are divergent and almost attain the posterior margin of the scutum; no lateral carinae; emargination shallow; scapulae shallow and rounded.

Anal grooves.—A little divergent posteriorly.

Spiracular plate.—Broadly oval or subcircular, the longer axis transverse, 0·11–0·13 mm by 0·13–0·16 mm.

Legs.—Slender and relatively long; coxae unarmed; tarsi tapering gradually, tarsus I 0·46–0·48 mm long, tarsus IV 0·46–0·50 mm long.

Larva

The larva has been described by Bedford (1934) and by Arthur (1956*a*). The diagnostic characters include: basis capituli as in nymph; scutum slightly longer than wide, finely punctate, cervical grooves not attaining posterolateral margins; coxae as in nymph; tarsus I 0·13 mm in length.

Hosts and Distribution

The specimens identified by the author as this subspecies are from "bat", Lismore, N.S.W., 17.viii.1958, 3 ♀♀; from *Miniopterus schreibersii*.* Narrangullen

*This is the host name shown on the legend and probably refers to *M. schreibersii blepotis*.

Cave, Wee Jasper, N.S.W., 9.x.1957, 2 ♀♀; and from *M. blepotis*, Teviotbrook, Qld., 10.x.1957, 1 ♀.

Comments

Arthur (1956*a*), after an examination of world-wide material, considered that there were two subspecies of *I. simplex*, namely *I. simplex simplex* and a new subspecies *I. s. africanus*. The distribution of the former subspecies as given by Arthur (1956*a*), Hoogstraal (1956), and Anon (1957) includes France, Greece, Palestine, Belgian Congo, Kenya, North Africa, Cape Colony, India, Japan, and Shanghai. This subspecies is now also recorded from Australia.

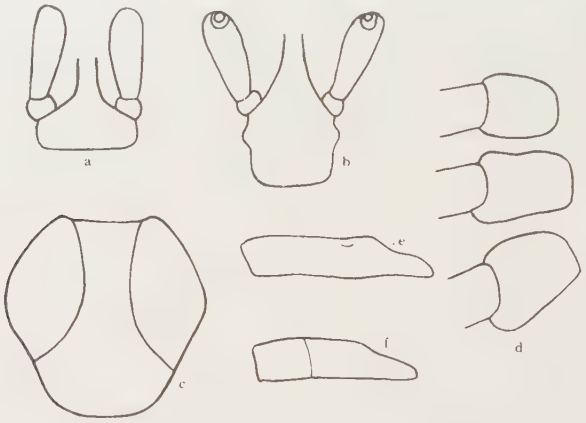

Fig. 11.—*I. vespertilionis*, larva: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, coxae; *e*, tarsus I; *f*, tarsus IV.

Ixodes vespertilionis Koch

Ixodes vespertilionis Koch, 1844, p. 37, fig. 9. Nuttall and Warburton, 1911, pp. 271–7, pl. vi, figs. 1 and 2, figs. 272–82 (includes synonymy to 1911). Ferguson, 1925, p. 29. Fielding, 1926, pp. 32–3, fig. 6. Johnston, 1937, p. 14. Taylor and Murray, 1946, p. 41. Pomerantzev, from Anastos, 1950, pp. 52–3. Arthur, 1956*a*, pp. 180–4, figs. 1–13. Hoogstraal, 1956, pp. 568–73, pl. lxvii, figs. 232–5. Anon, 1957, p. 25, pl. 39. Starkoff, 1958, pp. 160–7, plates 20, 21.

Eschatocephalus vespertilionis Arthur, 1953, pp. 161–72; 1956*b*, pp. 280–1, figs. 30–33.

This species was recorded from Australia by Nuttall and Warburton (1911) from a single nymph from a bat, "*Vesperugo bicolor*, Kingswilliamstown, South Australia." Johnston (1937) reported that the locality was South African, not Australian, and Hoogstraal (1956) noted that in addition to this error in locality, the specific name "*bicolor*" for the host could be referred only to an African species of Chiroptera. Fielding (1926), however, has reported this tick from "bats", north Queensland, and the present author has seen a larva which he considers to be this species from *Miniopterus blepotis*, Wombean Caves, N.S.W., collected on 5.ix.1959. A description of this larva is given below (see also Fig. 11):

Body.—Semi-engorged, 0·93 by 0·70 mm.

Capitulum.—0·24 mm in length; basis dorsally triangular, surface smooth, posterior margin straight; basis ventrally with a slight waist, no auriculae; palpi widest distally, 0·16 mm in length.

Hypostome damaged distally, dentition 2/2 basally then 3/3.

Scutum.—A little longer than broad, 0·40 by 0·36 mm, the greatest width at about mid-length; posterolateral margins a little concave, posterior angle broadly rounded; cervical grooves distinct, divergent posteriorly and attaining the posterolateral margins; emargination shallow; scapulae short and blunt.

Anal grooves.—Indistinct, divergent posteriorly.

Legs.—Very long and slender; coxae unarmed, flat; tarsus I and IV 0·34 mm in length.

Measurements given by Arthur (1956*a*) for the larva of this species are: capitulum 0·27 mm in length, scutum 0·43 by 0·41 mm, and tarsus I 0·37 mm, while for specimens received from Dr. Glen M. Kohls (ex bat, Hansu Tochigi Prep. Japan, 24.ii.1956), these measurements were 0·36 mm, 0·51 by 0·46 mm, and 0·44 mm respectively.

Ixodes ornithorhynchi Lucas

Ixodes ornithorhynchi Lucas, 1845, p. 58, fig. 3. Pagenstecher, 1861, p. 40, fig. 25. Neumann, 1899, pp. 142–4, figs. 18, 19; 1901, p. 285. Rainbow, 1906, p. 167. Nuttall and Warburton, 1911, pp. 242–3, figs. 236–8. Nuttall, 1916, p. 329. Ferguson, 1925, pp. 28, 35. Fielding, 1926, pp. 33–4, fig. 7. Taylor and Murray, 1946, pp. 52–3, figs. 51–3. Arthur, 1956*b*, p. 304. Kohls, 1957*a*, p. 85.

Coxiodes ornithorhynchi Schulze, 1941, p. 508.

The male of this species is unknown.

Female

Fig. 12, *a–i*

Diagnosis

Body with pale hairs; scutum wider than long, punctations fine, more numerous and relatively coarser laterally, no lateral carinae, cervical grooves obsolete anteriorly; capitulum relatively short, no cornua, no auriculae, hypostome dentition 3/3; anal grooves subparallel posteriorly; coxae unarmed.

Description

Body.—Measurements of partly fed and engorged specimens, 3·6–10·0 mm by 2·3–5·7 mm; marginal groove shallow and complete, disappearing on engorgement; posterolateral and median grooves well defined; numerous pale hairs dorsally and ventrally.

Capitulum.—Length 0·71–0·86 mm; basis dorsally 0·55–0·58 mm wide, the posterior margin usually straight, the posterolateral margins a little divergent anteriorly, no cornua, but sometimes posterolateral angles slightly swollen; porose areas superficial, large, usually subcircular, the interval occasionally swollen and about half the width of one, but sometimes oval or irregular in shape and in a few

specimens contiguous; basis ventrally with the posterior margin a little rounded, slightly waisted, the transverse suture indistinct, no auriculae; palpi 0·53 mm in length, article 1 rounded, wider than long, and ventrally with an anteroposterior ridge-like extension, article 2 relatively narrow basally, broadening distally, article 3 as wide as article 2 but not as long.

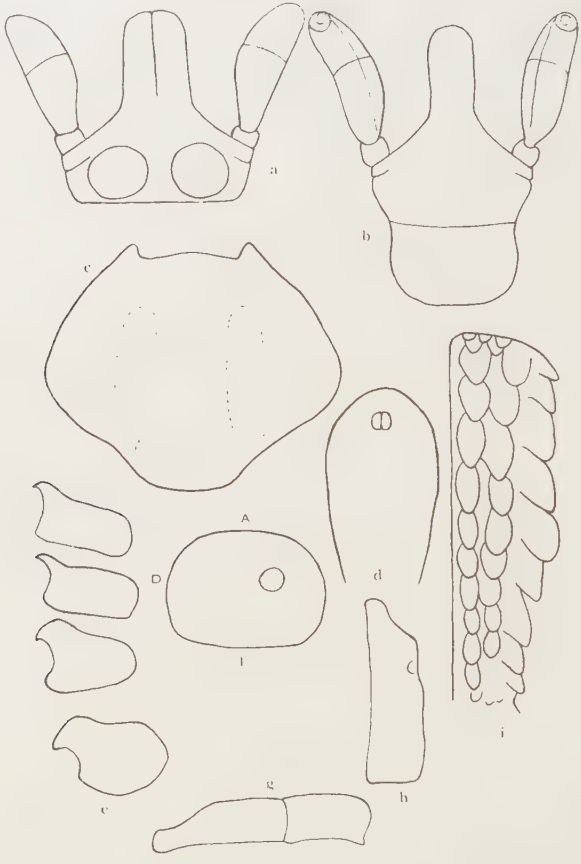

Fig. 12.—*I. ornithorhynchi*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, anal grooves; *e*, coxae; *f*, spiracular plate; *g*, tarsus IV; *h*, tarsus I; *i*, hypostome.

Hypostome about 0·45 mm in length, broadly spatulate, dentition 3/3, sometimes 2/2 basally, of about 8–9 teeth, the files and rows becoming progressively smaller inwardly and posteriorly.

Scutum.—Wider than long, 1·2–1·6 mm by 1·4–1·9 mm and widest at about mid-length; no lateral carinae; anterolateral margins a little sinuous, posterolateral margins concave, posterior angle broadly rounded; punctations fine, more numerous and relatively coarser laterally and posteriorly, where they are frequently confluent; cervical grooves wide and shallow, disappearing anteriorly, almost attaining

the posterolateral margins posteriorly; emargination well defined; scapulae bluntly pointed and sometimes a little ventriflexed; some relatively long, pale hairs.

Genital aperture.—In partly fed specimens at level of anterior margin of coxa III, but moving a little posteriorly on engorgement.

Genital grooves.—Straight and divergent to the level of anus, then curving convergently to reach the posterior margin of the body.

Anal grooves.—Rounded anteriorly, subparallel posteriorly.

Spiracular plate.—Large, broadly oval or subcircular, macular anterior and ventral to centre, about 0·53–0·57 mm by 0·57–0·68 mm.

Legs.—Length moderate; coxae elongate, slightly convex, unarmed; tarsi II–IV tapering gradually, tarsus I tapering more abruptly.

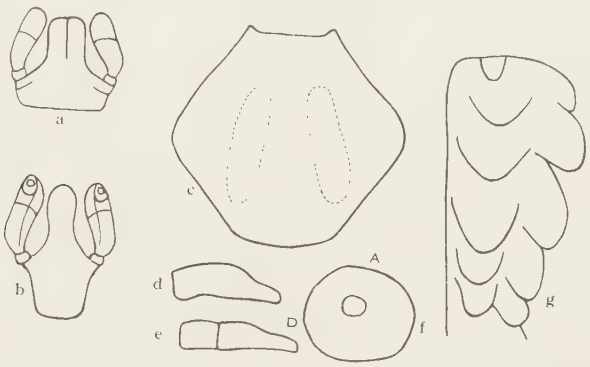

Fig. 13.—*I. ornithorhynchi*, nymph: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, tarsus I; *e*, tarsus IV; *f*, spiracular plate; *g*, hypostome.

Nymph

Fig. 13, *a–g*

Diagnosis

Scutum wider than long, the cervical grooves shallow and obsolete anteriorly; basis capituli and palpi as in female; hypostome dentition 2/2; anal grooves wide open posteriorly; legs as in female.

Description

Body.—Pale, oval, 1·5–3·2 mm by 0·9–2·15 mm, with scattered pale hairs.

Capitulum.—Length about 0·33 mm; basis dorsally almost rectangular, 0·3 mm wide, posterolateral margins a little divergent anteriorly, posterolateral angles frequently dark; basis ventrally with rounded posterior margin; palpal articles 2 and 3 about 0·21 mm in length, narrow basally, widest at mid-length, where the width is about half the length, article 3 not as long as article 2, article 1 rounded with a ventral, ridge-like extension as in the female.

Hypostome spatulate, dentition 2/2 of about 5 rows of large, blunt teeth.

Scutum.—Wider than long, 0·52–0·59 mm by 0·66–0·72 mm, widest at about mid-length; margins and posterior angle as in the female; punctations few, fine.

and mainly in lateral fields; cervical grooves not distinct except in region of mid-scutum where they appear as shallow, slightly divergent depressions; emargination moderate; scapulae bluntly pointed, some long hairs anteriorly and laterally.

Anal grooves.—Wide apart posteriorly, subparallel but frequently a little divergent.

Spiracular plate.—Broadly oval, the longer axis transverse, 0·20 by 0·24 mm.

Legs.—As in female.

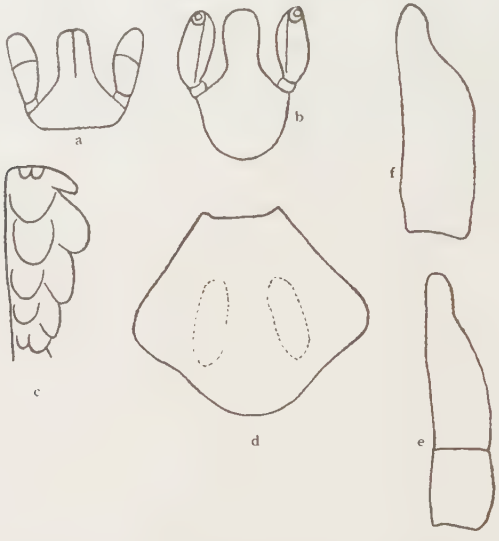

Fig. 14.—*I. ornithorhynchi*, larva: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, hypostome; *d*, scutum; *e*, tarsus IV; *f*, tarsus I.

Larva

Fig. 14, *a–f*

Diagnosis

Scutum wider than long, cervical grooves indistinct, as in the nymph; palpi broad; hypostome dentition 2/2; coxae unarmed; anal grooves indistinct, wide apart posteriorly.

Description

Body.—Length about 0·33 mm, pale, with scattered long, pale hairs.

Capitulum.—Length about 0·16 mm; basis dorsally 0·15 mm wide and slightly more than twice as wide as long, the posterolateral margins very short; palpi as in nymph.

Hypostome about 0·11 mm in length, rounded distally, dentition 2/2 of about 5 rows of relatively large teeth.

Scutum.—Wider than long, 0·31 by 0·37 mm, surface finely granulated, no apparent punctations; cervical grooves indistinct, very short, as in nymph; some long, pale hairs.

Anal grooves.—Indistinct, wide apart posteriorly.

Legs.—As in nymph.

Hosts and Distribution

This species has been recorded only from the platypus, *Ornithorynchus anatinus*. Lucas (1845) did not give any locality for the specimens on which he based his description, but Neumann (1899) recorded Tasmania and "isles Mariannes". The record of the Mariana Is. in the Pacific is undoubtedly erroneous (Kohls 1957*a*). Neumann (1901) later recorded this tick from New South Wales. Nuttall (1916) added Western Australia and Ferguson (1925) included Victoria.

Material examined.—QUEENSLAND: Pine R., 30.xii.1952, 3 ♀♀; Toogoolawah, 24.x.1951, 2 ♀♀. NEW SOUTH WALES: Taronga Park Zoo, 24.viii.1927, 1 ♀, 5 ♂♂. VICTORIA: Melbourne Zoo, 1 ♀; Mortlake, 22.xi.1912, 1 ♀; Lilydale, 22.iv.1926, 1 ♀; Ferntree Gully, 4.xi.1959, 3 ♂♂; Western District, 16.xi.1910, 1 ♀. TASMANIA: 2 ♀♀, 2 ♂♂; Bothwell, April 1939, 2 ♀♀, 5 ♂♂; Hobart, January 1949, 1 ♀; Mt. Wellington, 2 ♀♀, 2 ♂♂. SOUTH AUSTRALIA: Mt. Gambier, November 1955, 2 ♀♀, 2 ♂♂, 6 larvae. All these specimens with the exception of the female from Hobart were collected from *Ornithorhynchus anatinus*. The legend with the Hobart specimen gave the host as "blue-tongue" lizard.

Comments

According to Troughton (1951), *O. anatinus* inhabits the eastern region of Australia extending from north Queensland to Tasmania, and in the south extends to just within the border of South Australia. This casts some doubt on the record by Nuttall (1916) of the occurrence of this tick on *O. anatinus* in Western Australia. As further collections of this tick are made, it may possibly be found to have the same extensive distribution as its monotreme host.

I. ornithorhynchi is the only species of the genus known to infest the platypus, and it seems possible that the record of its occurrence on the blue-tongue lizard may be erroneous.

IXODES TASMANI Neumann

Ixodes tasmani Neumann, 1899, pp. 144–5, fig. 20. Rainbow, 1906, p. 167. Nuttall and Warburton, 1911, pp. 244–5, figs. 239, 240. Nuttall, 1916, pp. 321–4, fig. 20. Ferguson, 1925, p. 28. Fielding, 1926, p. 41, fig. 11. Taylor and Murray, 1946, pp. 54–6, figs. 54, 55. Seddon, 1951, p. 143.

Ixodes (*Endopalpiger*) *tasmani tasmani* Schulze, 1935, p. 38.

Ixodes (*Endopalpiger*) *tasmani victoriae* Schulze, 1935, pp. 31, 38, fig. 35. Arthur, 1951, p. 163.

Male

Fig. 15, *a–h*

Diagnosis

A small oval tick, with a well-defined, marginal body fold; article 1 of palpi enlarged, and extending towards base of mouthparts; hypostome dentition 2/2; scutum oval, punctations numerous, many relatively coarse and confluent; anal and adanal plates anteriorly and laterally straight, widest towards posterior margin of body; coxae unarmed, and with membranous outgrowths on posterior margin.

Description

Body.—Oval, 2·5–3·0 mm by 1·6–1·7 mm, narrowly rounded posteriorly, widest about mid-body region; marginal body fold well developed, extending from near a level with coxa IV, widening laterally and narrowing again posteriorly; hairs relatively few, small, and scattered.

Capitulum.—Short, about 0·36 mm in length; basis dorsally 0·32–0·35 mm wide, conspicuously punctate, posterior margin straight, posterolateral margins straight and divergent anteriorly; palpi wide apart, article 1 enlarged, rectangular dorsally, triangular ventrally, extending inwardly towards base of mouthparts, articles 2 and 3 indistinctly separated, 0·3 mm in length and twice as long as broad, narrower at base, otherwise of about equal width throughout the length.

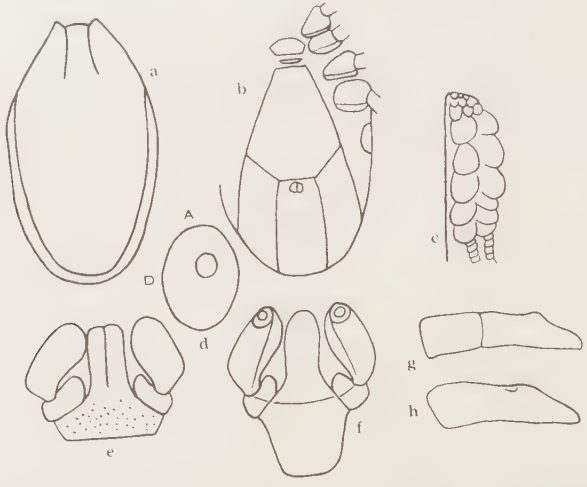

Fig. 15.—*I. tasmani*, male: *a*, body (dorsal view); *b*, body (ventral view); *c*, hypostome; *d*, spiracular plate; *e*, capitulum (dorsal view); *f*, capitulum (ventral view); *g*, tarsus IV; *h*, tarsus I.

Hypostome 0·19 mm in length, somewhat spatulate, dentition with 2 rows of 4/4 small teeth distally, then 7 rows of 2/2 large teeth, with a few rows of 2/2 tiny, shallow, crowded, ridge-like teeth basally.

Scutum.—Elongate oval, 2·3–3·0 mm by 1·4–1·6 mm, convex, narrowly rounded posteriorly and widest in region between coxae III and IV; no lateral grooves or carinae; punctations very numerous, finer medianly, otherwise relatively coarse with some confluency, particularly anteriorly; cervical grooves somewhat shallow and punctate anteriorly, extending posteriorly as shallow divergent depressions; emargination moderate; scapulae bluntly pointed.

Genital aperture.—In second intercoxal space.

Ventral plates.—Pregenital plate hexagonal, broader than long; median plate, 1·0 by 0·6 mm, widest posteriorly; anal plate 0·7 by 0·3 mm, anterior margin straight, lateral margins straight and a little divergent; adanal plates 0·8 by 0·3

mm, slightly wider posteriorly than anteriorly, the external margins slightly curved convergently; all plates with numerous punctations.

Spiracular plate.—Oval, 0·026 by 0·020 mm, the longer axis directed anteriorly.

Legs.—Slender, coxae contiguous, or almost so, increasing in size posteriorly, unarmed, with membranous outgrowths on posterior margins; tarsi tapering a little abruptly; tarsus I about 0·42–0·50 mm in length, tarsus IV about 0·46–0·52 mm in length.

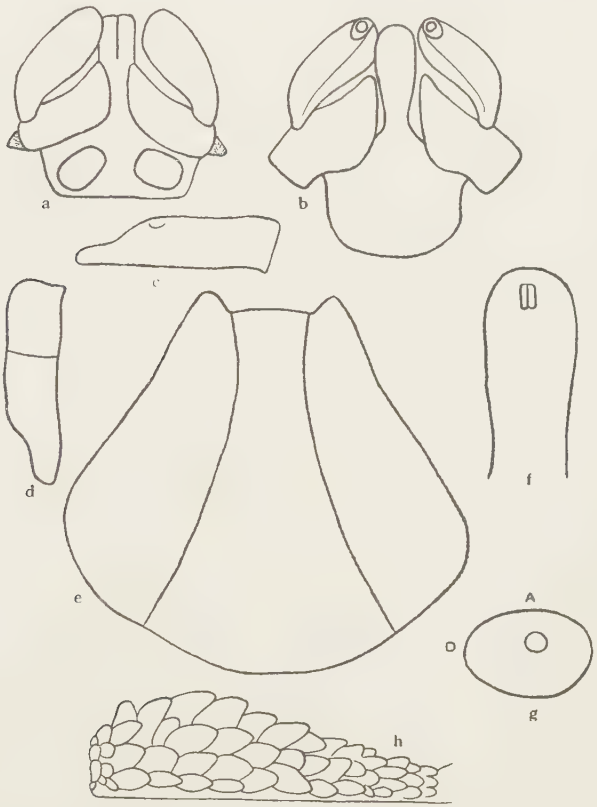

Fig. 16.—*I. tasmani*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, tarsus I; *d*, tarsus IV; *e*, scutum; *f*, anal grooves; *g*, spiracular plate; *h*, hypostome.

Female

Fig. 16, *a–h*

Diagnosis

A rather large tick on engorgement; the capitulum short, palpi broad, article 1 of palpi much enlarged and ensheathing base of mouthparts, porose areas oval, of moderate size, convergent anteriorly; hypostome spatulate, dentition variable but mainly 3/3; scutum a little wider than long and widest behind the middle,

with numerous relatively coarse punctations; coxae unarmed, and with membranous outgrowths on posterior margin.

Description

Body.—Unfed specimens 2·4–2·6 mm by 1·4–1·6 mm, flat, oval, and widest just anterior to spiracular plates; engorged specimens 8·0–11·8 mm by 5·0–5·6 mm, broadly ovoid: marginal groove in unfed specimens deep and complete, disappearing on engorgement; posterolateral and median grooves well defined; hairs small, scattered, sometimes almost lacking.

Capitulum.—Short, 0·48–0·66 mm in length; basis dorsally 0·38–0·51 mm wide, posterior margin straight or slightly convex, posterolateral margins straight, a little divergent anteriorly, no cornua, but sometimes posterolateral angles somewhat swollen; porose areas well defined, moderate in size, usually oval, convergent anteriorly, the interval relatively narrow and forming a mild depression; basis ventrally with posterior margin a little convex, no auriculae; palpi short and broad, their bases widely separated, article 1 greatly enlarged, extending inwardly and anteriorly to ensheathe base of mouthparts, rectangular dorsally, ventrally triangular, and strongly salient laterally to be visible dorsally, the posterior margin extending to a point towards the mid-line over the anterior prolongation of coxa I; articles 2 and 3 0·40–0·45 mm in length, narrow at base and broadening rapidly to a width of about one-third the length, sometimes finely granulated, apex rounded.

Hypostome short, 0·22–0·24 mm in length, spatulate, the apex broadly rounded; dentition with the teeth rather crowded, arrangement somewhat variable with 5–7 rows of 4/4 followed by 8–5 rows of 3/3, basally the teeth minute and sometimes 2/2; one specimen had 1 row of 4/4, 9 rows of 3/3 relatively large teeth on one side, and 8 rows of 4/4 and 2 rows of 3/3 relatively large teeth on the other.

Scutum.—Wider than long, 1·2–1·6 mm by 1·3–1·7 mm, and widest a little posterior to mid-length; convex; no lateral carinae; anterolateral margins straight or slightly sinuous, posterolateral margins mildly convex or slightly sinuous, the posterior angle very broad and rounded: punctations numerous, finer medianly and anteriorly, somewhat denser, coarser, and frequently confluent laterally, but sometimes relatively coarse throughout; cervical grooves well defined and convergent anteriorly, extending posteriorly as shallow divergent depressions, and usually attaining the posterolateral margins; emargination relatively deep; scapulae bluntly pointed.

Genital aperture.—In unfed specimens at level of coxa III but, as engorgement proceeds, moving towards second intercoxal space.

Genital grooves.—Well defined, divergent but curving convergently towards the posterior margin of the body.

Anal grooves.—Broadly convex anteriorly, then subparallel or curving gently convergently posteriorly to become divergent towards the posterior body margin.

Spiracular plate.—Small, ovoid, the longer axis transverse, 0·28–0·35 mm by 0·34–0·42 mm, the macula anterior to centre.

Legs.—Length moderate; coxae unarmed, flat, the posterior margins with membranous outgrowths; tarsi slender with relatively weak subterminal humps, tarsus I about 0·50–0·55 mm long, tarsus IV about 0·53–0·58 mm long.

Nymph

Fig. 17, *a–g*

Diagnosis

Scutum, palpi, and legs similar to those of female; hypostome dentition 2/2.

Description

Body.—Oval, 1·7–2·8 mm by 1·0–2·0 mm, with sparse, scattered, pale hairs.

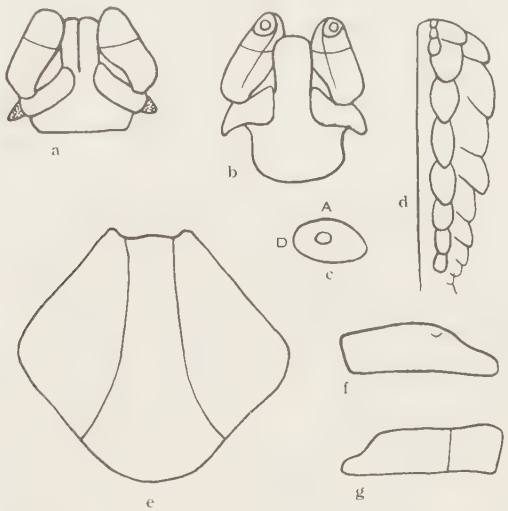

Fig. 17.—*I. tasmani*, nymph: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, spiracular plate; *d*, hypostome; *e*, scutum; *f*, tarsus I; *g*, tarsus IV.

Capitulum.—Length about 0·26 mm; basis about 0·24 mm wide, sometimes a few punctations dorsally, the posterior and posterolateral margins straight, the latter a little divergent anteriorly; palpi with article 1 somewhat as in female, articles 2 and 3 about 0·17 mm long, broadening medianly, article 3 rounded apically, as broad as article 2, but not as long.

Hypostome rounded apically, about 0·17 mm long, dentition 2/2 of about 8 teeth, the basal rows fine and delicate.

Scutum.—Broader than long, 0·53 by 0·76 mm; punctations, cervical grooves, emargination, and scapulae as in female.

Anal grooves.—Subparallel posteriorly in unfed specimens, but curving gently convergently in engorged specimens.

Spiracular plate.—Oval, the longer axis transverse, about 0·08 by 0·14 mm.

Legs.—As in female.

Larva

Fig. 18, *a–f*

Diagnosis

Scutum wider than long, the cervical grooves attaining the posterolateral margin; article 1 of palpi enlarged, extending inwards to base of mouthparts and ventrally with posterior margin as in female and nymph, articles 2 and 3 very broad; dentition 2/2; coxae unarmed.

Description

Body.—Unfed larva 0·67 by 0·57 mm, partly engorged larva, 1·1 by 0·7 mm, oval, with some minute hairs.

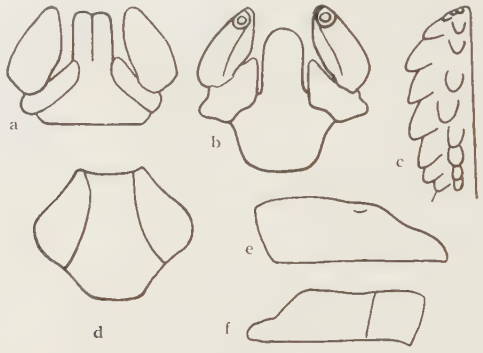

Fig. 18.—*I. tasmani*, larva: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, hypostome; *d*, scutum; *e*, tarsus I; *f*, tarsus IV.

Capitulum.—Length about 0·14 mm; basis shape dorsally as in nymph, about 0·15 mm wide; palpal article 1 enlarged, dorsally extending inwardly to base of mouthparts, the ventral, lateral salience rounded and not as pronounced as in female and nymph, articles 2 and 3 short and broad converging towards apex of mouthparts, 0·08 mm long, widest medianly, the external margin angulated, article 3 not as long as article 2.

Hypostome rounded apically, about 0·08 mm long; dentition 2/2 of about 8 teeth.

Scutum.—Wider than long, 0·21–0·28 mm by 0·34–0·36 mm, and widest about mid-length, glossy, finely granulated; cervical grooves as in female and nymph.

Anal grooves.—Subparallel posteriorly.

Legs.—Coxae unarmed, tarsi 0·18 mm in length, tapering gradually.

Hosts and Distribution

I. tasmani was originally described by Neumann (1899) from females from unknown hosts from Tasmania and St. Piere I., Bass Strait. Nuttall (1916) added *Trichosurus vulpecula*, Queensland, and *Dasyurops maculatus*, *Schoinobates volans*, and *Phascolarctos cinereus*, Victoria. Ferguson (1925) recorded the species from a "possum", Eidsvold, Qld., and Seddon (1951) mentioned it as occurring on dogs in Tasmania.

Material examined.—QUEENSLAND: *Isoodon obesulus*, Brisbane, 29.viii.1953, 2 ♀♀, 5 ♂♂; *I. obesulus*, Brisbane, 2.x.1958, 2 ♂♂ (bred from nymph); larvae bred from female from "bandicoot", Brisbane, October 1958; *Hydromys chrysogaster*, Brisbane, 23.vii.1959, 11 ♂♂, 1 larva; *Melomys cervinipes*, Springbrook, 15.vi.1959, 3 larvae; *Conilurus albiceps*, Mt. Tamborine, 31.v.1951, 2 ♀♀; *Phascolarctos cinereus*, Wellington Point, 1.ii.1903, 1 ♀; *Trichosurus vulpecula*, Ipswich, 1 ♀, 1 ♂; *T. vulpecula*, Yalungar, July, 1915, 5 ♀♀; *T. vulpecula*, Ipswich, August 1910, 3 ♀♀; *T. vulpecula*, Brisbane, 3 ♀♀; *Petaurus* sp., Mt. Nebo, 23.xi.1956, 1 ♀; "possum", Gayndah, 1 ♀; "possum", Murphy's Creek, 12.ix.1950, 1 ♀; "possum", Emerald, 1 ♀; "possum", Harrisville, 9.xii.1910, 2 ♀♀; "possum", Bundaberg, 3.vii.1906, 1 ♀; "possum", Roma, 26.ix. 1917, 1 ♀; *Felis catus*, Brisbane, 12.ix.1950, 2 ♀♀; *F. catus*, Brisbane, 7.ix.1951, 2 ♀♀; *Canis familiaris*, Brisbane, 8.x.1952, 2 ♀♀; *Equus caballus*, Maryborough, 2.viii.1930, 1 ♀; *F. catus*, Brisbane, 1 ♀; *Rattus assimilis*, Mt. Glorious, 2 ♂♂; *R. norvegicus*, Mt. Glorious, 2 larvae; "rabbit-rat", Tamborine, July 1948, 2 ♂♂; "rat", Brisbane, 7.ix.1950, 2 ♂♂, 2 larvae; *Uromys* sp., Ravenshoe, January 1951, 1 ♂; man, Boyne Valley, November 1915, 1 ♂; man, Brisbane, 29.iii.1957, 1 ♀. NEW SOUTH WALES: *Pseudocheirus laniginosus*, Lismore, 2.ix.1928, 1 ♀; *P. cinereus*, Tweed R., August 1902, 1 ♀; *T. vulpecula*, Canberra district, 11.v.1957, 8 ♀♀, 5 ♂♂, 2 larvae; *T. vulpecula*, Canberra district, 28.x.1958, 1 ♂, 4 ♂♂; *T. vulpecula*, Yass, 24.i.1934, 2 ♀♀, 1 ♂; *Antechinus flavipes*, 5 larvae; "wombat", Cooma, October 1951, 1 ♀; *C. familiaris*, Laura, 1 ♀; *C. familiaris*, Towae, 13.iii.1924, 1 ♀; *A. flavipes*, 1 ♂; Woodenbong, 1 ♀; Bethrungra Hills, 5.x.1938, 1 ♀; "possum", The Brook, 26.vi.1930, 1 ♀; Moree, 8.iv.1949, 1 ♀. VICTORIA: *F. catus*, Markwood, 11.x.1955, 1 ♀; *F. catus*, Carrajung, 6.iii.1959, 1 ♀; *P. cinereus*, Sassafras, 1 ♀; "marsupial rat", Tooborac, 6.vii.1928, 1 ♀, 1 ♂; Cape Otway, 24.xi. 1949, 1 ♀; *Oryctolagus cuniculus*, Western District, November 1958, 1 ♀; man, Gippsland district, 7.iii.1959, 1 ♀. SOUTH AUSTRALIA: *Pseudocheirus* sp., Adelaide, 1 ♀; *Protemnodon* sp., 1 ♀; "possum", Bordertown, October 1904, 1 ♀. WESTERN AUSTRALIA: *Hydromys fuliginosus*, Swan R., Perth, 4 ♀♀. TASMANIA: 2.xii.1928, 1 ♀; Prince Arthur Range, January 1949, 1 ♀; *Sarcophilus harrisii*, Hobart, 10.ii.1950, 1 ♀; "tiger cat", Arthur R., 13.v.1951, 1 ♀; "wombat", Gretna, 24.iii.1960, 3 ♀♀.

Comments

The females showed some degree of variation, particularly in the dentition, in the shape of palpal article 1 ventrally, in the shape and punctation of the scutum, and in the shape of the porose areas. The variations in the dentition have already been discussed. Odd specimens have been seen with the scutum somewhat approaching that of *I. fecialis* in shape and as figured by Neumann (1899), and with the scutal punctations irregularly distributed. The ventral posterior margin of palpal article 1 usually conformed to the figure accompanying the description by the author, but occasional specimens were seen with a much more pronounced notch in this margin. The porose areas were usually oval, but some specimens showed some variation from this shape, which in one female was triangular with a very narrow interval. The variations in the appearance of palpal article 1 ventrally and in the shape and punctation of the scutum and in the sculpturing of the palpi prompted Schulze (1935) to describe two subspecies, namely *I. tasmani tasmani* and

I. tasmani victoriae, but in the present author's opinion, the erection of these subspecies is not warranted.

The description of the male by Nuttall (1916) is very brief and inadequate and was taken from a mounted specimen. The description given in this revision is based on two males bred from nymphs collected from *I. obesulus* and a male taken on *A. flavipes*.

Ixodes hydromyidis Swan

Ixodes hydromyidis Swan, 1931, pp. 485–6, fig. 1. Taylor and Murray, 1946, pp. 64–5, fig. 71.

Ixodes (*Endopalpiger*) *hydromyidis* Schulze, 1935, p. 38.

The male of this species is unknown.

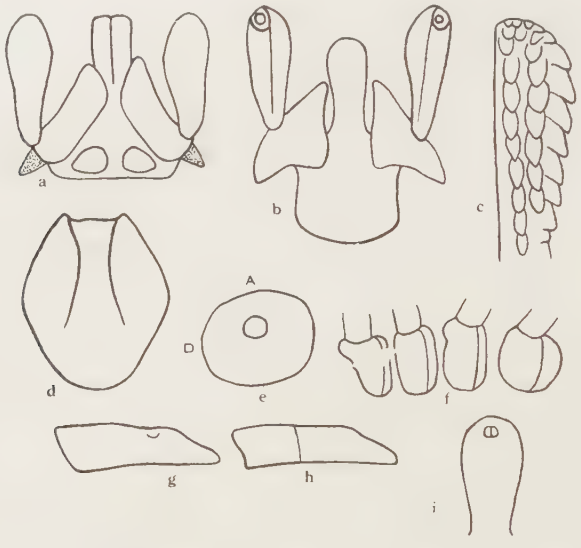

Fig. 19.—*I. hydromyidis*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, hypostome; *d*, scutum; *e*, spiracular plate; *f*, coxae; *g*, tarsus I; *h*, tarsus IV; *i*, anal grooves.

Female

Fig. 19, *a–i*

Diagnosis

Scutum a little longer than wide and widest about mid-length; punctations fine and scattered, no lateral carinae; palpal article 1 greatly enlarged, ensheathing base of mouthparts, ventrally strongly salient laterally; porose areas superficial; no auriculae; hypostome dentition mainly 3/3; anal grooves subparallel posteriorly; coxae unarmed.

Description

Body.—Unfed specimens 3·6 by 2·0 mm, engorged specimens 6·2 by 3·8 mm; elongate oval; scutum, capitulum, and legs pale; posterolateral and median grooves

well defined; numerous, short, pale hairs which become scattered as engorgement proceeds.

Capitulum.—Length 0·43–0·50 mm; basis dorsally somewhat triangular, 0·32 mm wide, the posterior margin straight, no cornua, the posterolateral margins short, straight, divergent anteriorly; basis ventrally rounded posteriorly, no auriculae; porose areas superficial, the pits comparatively large, shallow, and few, the interval not quite equal to the width of one; palpi wide apart, article 1 greatly enlarged, extending inwardly to ensheathe base of mouthparts, dorsally rectangular, ventrally triangular and strongly salient laterally, the ventral lateral salience prominent when viewed dorsally; articles 2 and 3 apparently fused, 0·34 mm in length, clavate, widest distally, where the width equals about one-third the length.

Hypostome clavate, the apex broadly rounded; dentition with 2 rows of 4/4 distally, then 7 rows of 3/3 and 3 rows of 2/2 basally.

Scutum.—Longer than wide, 0·80–0·97 mm by 0·72–0·80 mm, and widest slightly anterior to mid-length; punctations relatively few, fine, and scattered; anterolateral margins straight or slightly convex, posterolateral margins a little concave or sinuous, posterior angle broadly rounded; cervical grooves posteriorly divergent and superficial, not attaining the posterior margin; emargination relatively shallow; scapulae bluntly pointed; a few, short, scattered pale hairs.

Genital aperture.—At level with coxa III.

Genital grooves.—Long, diverging gently.

Anal grooves.—Rounded anteriorly, subparallel or gently convergent posteriorly.

Spiracular plate.—Subcircular or broadly oval, the longer axis transverse, about 0·24 by 0·30 mm.

Legs.—Relatively long, slender; coxae unarmed, the posterior margins trenchant; tarsi tapering gradually, tarsus I 0·46 mm long, tarsus IV 0·58 mm long.

Nymph

Fig. 20, *a–c*

Diagnosis

Scutum a little broader than long; capitulum as in female, hypostome dentition 2/2; coxae unarmed; anal groove subparallel posteriorly.

Description

Body.—Oval, 1·42–1·60 mm by 0·87–0·95 mm, with scattered, pale hairs.

Capitulum.—Length 0·26 mm; basis 0·25 mm wide, shape as in female; palpi as in female.

Hypostome broadly rounded apically, dentition 2/2 of 7–8 teeth.

Scutum. –Broader than long, 0·40–0·43 by 0·48–0·52 mm; punctations and cervical grooves as in female.

Anal grooves.—As in female.

Spiracular plate.—Broadly oval, the longer axis transverse, 0·14 by 0·17 mm.

Legs.—As in female; tarsus I about 0·3 mm long, tarsus IV about 0·3 mm long.

Larva

Fig. 20, *d–g*

Diagnosis

Scutum broader than long; palpal article 1 enlarged and ensheathing mouthparts basally, articles 2 and 3 fused, converging anteriorly with the external margin angulated basally; hypostome dentition 2/2; anal grooves divergent posteriorly; coxae unarmed.

Description

Body.—Measurements 0·7 by 0·5 mm, widest behind coxa III, some scattered bristle-like hairs.

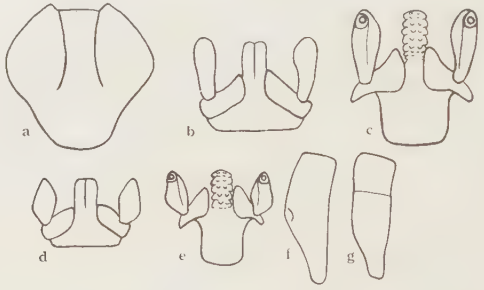

Fig. 20.—*I. hydromyidis*, nymph (*a–c*) and larva (*d–g*): *a*, scutum; *b*, capitulum (dorsal view); *c*, capitulum (ventral view); *d*, capitulum (dorsal view); *e*, capitulum (ventral view); *f*, tarsus I; *g*, tarsus IV.

Capitulum.—Length about 0·11 mm; basis dorsally triangular, about 0·10 mm wide, posterolateral and posterior margins straight; palpal article 1 enlarged as in female, articles 2 and 3 fused, 0·08 mm long, broad, external margin angulated near base, apex rounded.

Hypostome 2/2 of about 5 teeth.

Scutum.—Wider than long, about 0·30 by 0·39 mm and widest about mid-length; median fields flat, lateral fields convex, posterior angle broadly rounded; cervical grooves indistinct; emargination shallow; scapulae rounded.

Anal grooves.—Divergent posteriorly.

Legs.—Coxae unarmed; tarsus I about 0·19 mm long, tarsus IV about 0·15 mm long.

Hosts and Distribution

I. hydromyidis is known only from Western Australia. Swan (1931) recorded his material from the water-rat, *Hydromys fuliginosus*, and from the black rat *Rattus rattus*, Mundaring Weir, Kalamunda. Specimens seen by the author were collected from *Rattus* sp., Fremantle, namely 3 ♀♀, 5 ♂♂, 6 larvae, May 1952; 3 ♂♂, April 1943; and 2 ♂♂, November 1936.

Comments

The specimens of females and nymphs examined by the author agreed very closely with the descriptions given by Swan (1931). The larva is described for the first time. Of the Australian species of *Ixodes* with a greatly enlarged palpal article 1, *I. hydromyidis* is closest to *I. tasmani*, as in both species the coxae are unarmed. The shape and punctation pattern of the scutum, the type of porose areas, and the hypostome dentition readily distinguish the females of these two species.

Ixodes victoriensis Nuttall

Fig. 21, *a–j*

Ixodes victoriensis Nuttall, 1916, pp. 297–8, fig. 3. Ferguson, 1925, p. 28. Fielding, 1926, pp. 51–2, fig. 19. Taylor and Murray, 1946, pp. 63–4, fig. 70.
Ixodes (*Endopalpiger*) *victoriensis* Schulze, 1935, p. 38.
Not *Ixodes victoriensis*. cf. Hirst, 1930, pp. 575–6.

The male, nymph, and larva of this species are unknown.

Female

Diagnosis

Scutum a little broader than long; capitulum short, porose areas well apart, cornua strong, auriculae small; palpal article 1 greatly enlarged, ensheathing basal half of mouthparts, its posterior border ventrally strongly notched; anal grooves slightly convergent, but wide apart posteriorly; legs stout, coxae each with a blunt inwardly directed, external spur; each tarsus with pronounced subterminal hump, that on tarsi II–IV extending forward as a spiniform protruberance.

Description

Body.—Partly engorged specimens 5·6–6·9 mm by 3·2–4·2 mm, widest just posterior to spiracles; marginal grooves not apparent, posterolateral and median grooves well defined; some scattered, small, pale hairs.

Capitulum.—Relatively short, about 0·6 mm long; basis dorsally subrectangular, broad, 0·65 mm wide, posterior margin sinuous with strong, incurved, blunt cornua, lateral margins short, curved and divergent anteriorly; porose areas irregularly broadly oval in shape, wide apart, and situated in a depressed area, bounded laterally and anteriorly by a fairly well-defined ridge; basis ventrally narrowing and rounded posteriorly with small blunt auriculae, transverse suture faintly visible; palpi short, with article 1 greatly enlarged, salient laterally, dorsally somewhat rectangular, and extending inwardly and anteriorly to ensheathe the basal half of mouthparts, ventrally the lateral salience is more pronounced and the posterior margin markedly extended posteriorly as a pointed process; articles 2 and 3 apparently fused, 0·35 mm long, narrow at base and widening rapidly to a width of about half the length.

Hypostome short, 0·4 mm long, clavate with a rounded apex; dentition distally 6/6 of very tiny teeth then 5–6 rows of 5/5, 1 row of 4/4, 1 row of 3/3, and 4 rows of 2/2 basally (in another specimen dentition was 1 row of 6/6, 1 row of 5/5 distally of very small teeth, then 7 rows of 4/4 and 4 rows of 2/2).

Scutum.—Slightly wider than long, 1·05–1·28 mm by 1·34–1·56 mm, widest just anterior to mid-length, anterolateral and posterolateral margins mildly sinuous, both lateral and posterior angles broadly rounded; no lateral carinae; punctations numerous and medium-sized in lateral and anteromedian fields, otherwise fine and

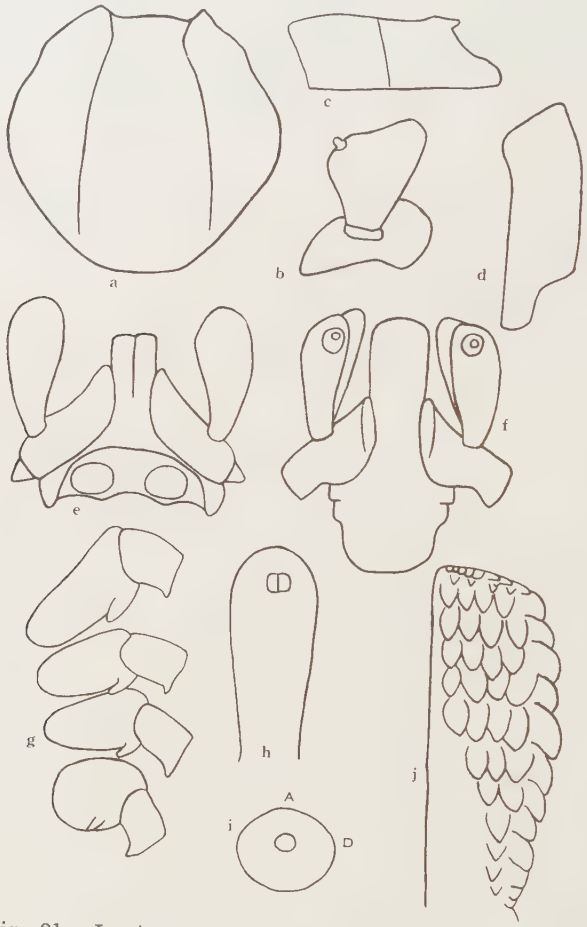

Fig. 21.—*I. victoriensis*, female: *a*, scutum; *b*, palp (lateral view); *c*, tarsus IV; *d*, tarsus I; *e*, capitulum (dorsal view); *f*, capitulum (ventral view); *g*, coxae and trochanters; *h*, anal grooves; *i*, spiracular plate; *j*, hypostome.

scattered; cervical grooves broad and distinct, continuing posteriorly as slightly divergent depressions which do not quite attain the posterior margin; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of anterior border of coxa III.

Genital grooves.—Almost straight and divergent to level of anus, then curved and convergent.

Anal grooves.—Rounded and sometimes somewhat indistinct anteriorly, rather elongate posteriorly where they curve gently convergently but become slightly divergent near posterior margin of body.

Spiracular plate.—Small, broadly oval, the longer axis transverse, 0·26 by 0·30 mm, the macula anterior to centre.

Legs.—Somewhat stout and of moderate length; coxae relatively narrow, each with a small, blunt, inwardly directed, external spur; trochanters with ventral rounded posteroexternal prominences; tarsi with strong subapical hump, the hump on tarsi II–IV extending forwards as a spiniform protruberance.

Hosts and Distribution

I. victoriensis was described by Nuttall (1916) from *Vombatus hirsutus* (= *Phascolomys mitchelli*), Victoria. The description by the present author is based on specimens labelled "wombat. Victoria, 20.ix.46", 1 ♀, and "wombat, Victoria." 28.i.1950, 2 ♀♀.

Comments

Four species of ticks have been recorded from wombats, namely *Aponomma auruginans* Schulze, which is common and widespread, *I. victoriensis*, *I. tasmani*, and *I. phascolomyis* Macalister, 1871. The description of *I. phascolomyis* is extremely vague and the species was condemned by both Neumann (1899) and Nuttall and Warburton (1911). Travassos-Santos Dias (1958), however, considered the description and illustration as adequate for determining its identity as *A. auruginans*, over which name Macalister's species took priority.

I. victoriensis is a distinctive species and cannot be confused with any other species of *Ixodes*. The shape of the scutum, the greatly enlarged palpal article 1, the stout legs, the coxal armature, and the forwardly directed spur on the preapical hump of tarsi II–IV will determine this species.

Ixodes australiensis Neumann

Ixodes australiensis Neumann, 1904, pp. 456–7, fig. 1. Nuttall and Warburton, 1911, pp. 250–2, figs. 247–9. Ferguson, 1925, p. 28. Fielding, 1926, pp. 44–5, fig. 13. Taylor and Murray, 1946, pp. 57–8, figs. 57–9. Seddon, 1951, p. 143.
Ixodes (*Endopalpiger*) *australiensis* Schulze, 1935, p. 38.

The male and larva of this species are unknown.

Female

Fig. 22, *a–i*

Diagnosis

Scutum wider than long and widest posterior to mid-length, with lateral and sometimes anterior rugae; capitulum short, porose areas wide apart, palpi short, wide apart, article 1 greatly enlarged and ensheathing base of mouthparts, and ventrally strongly salient laterally; dentition mainly 4/4; coxae each with an external spur; anal grooves meeting posteriorly at a point.

Description

Body.—Semi-engorged and engorged specimens 5·9–8·6 mm by 3·6–5·7 mm. (Nuttall and Warburton (1911) give measurements as 2·5–3·5 mm by 1·9–2·7 mm and these evidently refer to unfed or partly fed specimens), sides subparallel, and widest in region of spiracles; marginal groove complete and visible in engorged ticks as a faint line; posterolateral and median grooves well defined; apparently glabrous.

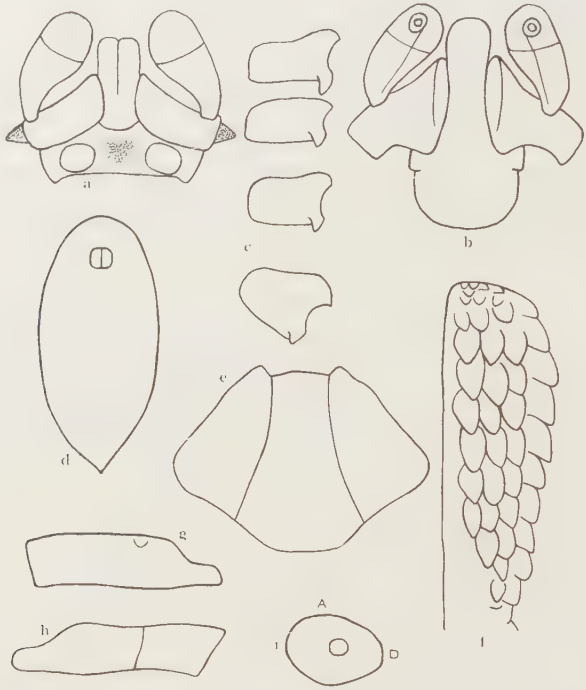

Fig. 22.—*I. australiensis*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, coxae; *d*, anal grooves; *e*, scutum; *f*, hypostome; *g*, tarsus I; *h*, tarsus IV; *i*, spiracular plate.

Capitulum.—Short, 0·46–0·51 mm in length; basis dorsally subrectangular, 0·46–0·53 mm wide, the posterior margin straight or slightly concave, the posterolateral angles rounded, raised, swollen, and forming small blunt cornua, the posterolateral margins curved and a little divergent anteriorly; porose areas wide apart, variable in shape, the outline irregular, triangular, irregularly oval or subcircular, extending a little convergently from near the posterolateral corners towards a median triangular depression; basis ventrally rounded posteriorly with auriculae as small tuberosites; palpi short and wide apart, article 1 greatly enlarged, extending inwardly and anteriorly to ensheathe basal half of mouthparts, dorsally rectangular in shape, ventrally triangular and strongly salient laterally and posteriorly, the salience visible dorsally, articles 2 and 3 separate, the suture ill defined, twice as long as wide and widest at about mid-length, article 3 broadly rounded apically.

Hypostome about 0·3 mm in length, spatulate, broadly rounded distally; dentition mainly 4/4 with 7 rows of large teeth, becoming 3/3 and 2/2 basally.

Scutum.—Distinctly wider than long, 0·9–1·1 mm by 1·4–1·5 mm and widest a little posterior to mid-length, anterolateral margins slightly sinuous, posterolateral margins slightly concave or sinuous, posterior angle very broad and rounded; no lateral carinae; cervical grooves well defined anteriorly, becoming shallow posteriorly, and extending to the posterolateral margins; punctations fine and scattered in median fields with rugae external to the cervical grooves and sometimes between these grooves anteriorly; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of coxa III, but in engorged specimens approaching level of coxa II.

Genital grooves.—Divergent to a point a little beyond level of anus, then curving convergently; sometimes very faint posterior to anus.

Anal grooves.—Elongate oval and meeting posteriorly at a point, becoming less distinct anteriorly in engorged specimens.

Spiracular plate.—Broadly oval, the longer axis transverse, about 0·24 by 0·30 mm.

Legs.—Slender and of moderate length; coxae flat, each with a mildly incurved, external spur, which become progressively smaller posteriorly; trochanters with ventral, mild, external tuberosities; tarsi tapering gradually, tarsus I 0·65–0·70 mm in length, tarsus IV 0·66–0·72 mm in length.

Nymph

Fig. 23, *a–i*

Diagnosis

Scutum wider than long, with rugae laterally; capitulum short, palpal article 1 enlarged to ensheathe base of mouthparts and ventrally strongly salient laterally, the posterior margin with a pointed salience; hypostome dentition 4/4; coxae with external spurs; anal grooves wide apart posteriorly.

Description

Body.—Unfed specimen oval, 1·2 by 0·9 mm, widest at about mid-length; marginal groove complete; hairs minute and scattered.

Capitulum.—Short, 0·26 mm in length; basis dorsally subrectangular; no distinct cornua, but posterolateral angles dark and somewhat raised; palpi as in female, the ventral posterior margin of article 1 extending posteriorly as a pointed salience, basis ventrally with rounded posterior margin and small, dark auriculae.

Hypostome clavate, about 0·1 mm in length; dentition mainly 4/4, becoming 5/5 distally, and 3/3 basally.

Scutum.—Wider than long, 0·54 by 0·67 mm, and widest somewhat posterior to mid-length; anterolateral margins straight, posterior angle broadly rounded; punctations fine and scattered, the lateral fields with conspicuous rugae; cervical grooves wide and deep, becoming shallow posteriorly to attain the posterolateral margins; emargination moderate; scapulae bluntly pointed.

Anal grooves.—Rounded anteriorly, converging a little posteriorly and remaining wide apart.

Spiracular plate.—Oval, the longer axis transverse, 0·08 by 0·11 mm.

Legs.—Coxae flat with moderate, pointed external spurs decreasing in size posteriorly; tarsi tapering gradually, tarsus I about 0·26 mm in length, tarsus IV about 0·24 mm in length.

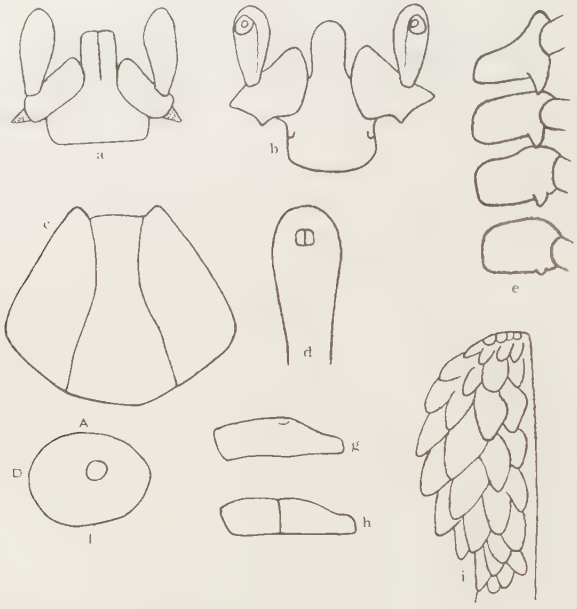

Fig. 23.—*I. australiensis*, nymph: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, anal grooves; *e*, coxae; *f*, spiracular plate; *g*, tarsus I; *h*, tarsus IV; *i*, hypostome.

Hosts and Distribution

I. australiensis was described by Neumann (1904) from females from *Canis* sp., Western Australia. Other records from this State include females from *C. familiaris*, Cranbrook, April 1900, and from *Bettongia lesueur*, Kogonup, November 1900 (Nuttall and Warburton (1911)).

Material examined.—WESTERN AUSTRALIA: "kangaroo", 2 ♀♀; no data, 3 ♀♀; cattle, Northcliffe, 1.iv.1935, 3 ♀♀; *C. familiaris*, Albany district, 1 ♀; *B. penicillata*, Dryandera, 27.i.1955, 2 ♀♀, 3 oo. According to Calaby (personal communication) this tick may frequently be taken in this State on *Setonix brachyurus*.

Comments

The nymph is described for the first time. It differs in several features from the female, and in particular in the widely open anal grooves.

The female and nymph of *I. australiensis* can be readily separated from *I. tasmani* and *I. hydromyidis*, which possess a similarly enlarged palpal article 1, by

the armed coxae and in the female also by the closed anal grooves. The nymph of the fourth species with this palpal character, *I. victoriensis*, is unknown, but would probably also possess armed coxae and also widely open anal grooves, but could possibly be recognized by the shape of the scutum.

Ixodes fecialis Warburton & Nuttall

Ixodes fecialis Warburton and Nuttall, 1909, pp. 58–9, figs. 1, 2; Nuttall and Warburton, 1911, pp. 248–9, fig. 245. Nuttall, 1916, p. 327. Ferguson, 1925, p. 28. Fielding, 1926, p. 51, fig. 18. Taylor and Murray, 1946, pp. 56–7, fig. 56.

Ixodes fecialis var. *aegrifossus* Warburton and Nuttall, 1909, pp. 56–60, fig. 3. Nuttall and Warburton, 1911, p. 250, fig. 246. Nuttall, 1916, p. 335.

Ixodes (*Exopalpiger*) *fecialis* Schulze, 1935, p. 37.

The larva of this species is unknown.

Male

Fig. 24, *a–h*

Diagnosis

A small, narrowly oval tick, with a very narrow, marginal body fold; capitulum short, palpi wide apart, basis with dorsal carinae; no cornua, no auriculae; dentition 2/2 of rounded teeth; scutum with numerous punctations; anal plate straight-sided, a little wider posteriorly than anteriorly, adanal plates rectangular; coxae unarmed with strongly developed, membranous outgrowths on posterior margin; tarsi tapering gradually.

Description

Body.—Narrowly oval and somewhat bluntly pointed posteriorly, twice as long as wide, 2·1 by 1·1 mm, and widest in region between coxae II and III; marginal body fold very narrow, commencing near coxa II and widening a little posteriorly; hairs pale and decumbent.

Capitulum.—Short, 0·28 mm in length; basis dorsally hexagonal, 0·26 mm wide, median field depressed, finely granulated, lateral fields swollen and glossy and separated from median field by well-defined carinae which extend from the posterolateral angles convergently to base of mouthparts; posterior margin straight, no cornua; posterolateral margins straight and divergent anteriorly; palpi wide apart, article 1 rounded, a little wider than long, articles 2 and 3 fused, narrow at base but broadening rapidly, the apex rounded, 0·18 mm in length, and with a maximum width of 0·11 mm.

Hypostome short and broad, shorter than palpi, 0·14 mm in length, sides parallel, apex rounded; dentition 2/2 of 5–6 rounded teeth.

Scutum.—Similar in shape to body, dimensions slightly smaller, bluntly pointed behind; punctations numerous; cervical grooves short, convergent; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of coxa II.

Ventral plates.—Pregenital plate small, wider than long; median plate straight-sided and hexagonal, widest at about two-thirds the length, 1·07 by 0·43 mm; anal

plate with anterior and lateral margins straight, a little wider posteriorly than anteriorly; adanal plates almost rectangular, the lateral sides almost straight.

Spiracular plate.—Somewhat egg-shaped, the narrower end posterior and the longer axis directed anteriorly, about 0·21 mm in length.

Legs.—Length moderate, comparatively stout; coxae unarmed and provided with strongly developed, membranous outgrowths on posterior margin; tarsi tapering gradually, tarsus I 0·37 in length, tarsus IV 0·40 mm in length.

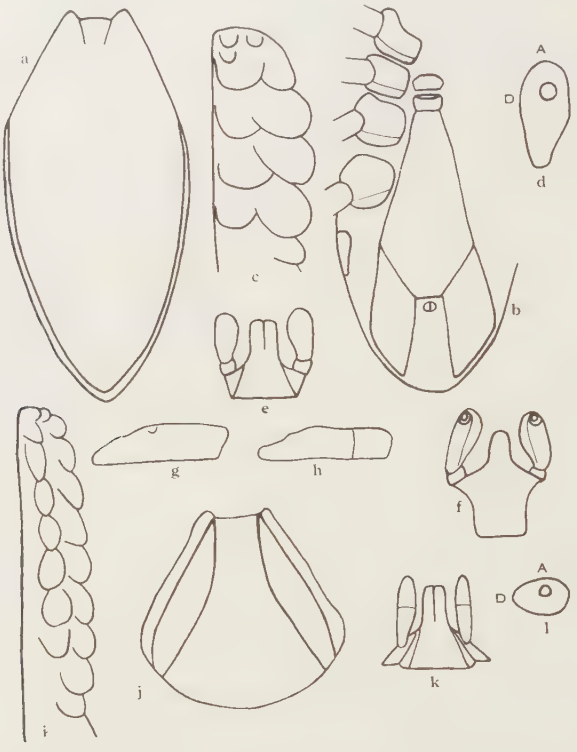

Fig. 24.—*I. fecialis*, male (*a–h*) and nymph (*i–l*): *a*, body (dorsal view); *b*, body (ventral view); *c*, hypostome; *d*, spiracular plate; *e*, capitulum (dorsal view); *f*, capitulum (ventral view); *g*, tarsus I; *h*, tarsus IV; *i*, hypostome; *j*, scutum; *k*, capitulum (dorsal view); *l*, spiracular plate.

Female

Fig. 25, *a–i*

Diagnosis

Scutum longer than wide and widest towards the posterior margin, lateral carinae well developed; capitulum relatively slender and of moderate length, article 1 of palpi enlarged, strongly salient laterally, and fused diagonally with basis, basis dorsally usually with carinae, no cornua, porose areas oval and convergent anteriorly; dentition 2/2; coxae unarmed and with well-developed membranous outgrowths on posterior margin; anal grooves subparallel or gently convergent behind.

Description

Body.—Unfed specimens elongate oval, 2·1–2·3 mm by 1·0–1·1 mm, widest in region of spiracles; marginal grooves complete and well defined; thickly clothed with pale, decumbent hairs; semi-engorged and engorged specimens, 5·7–11·7 mm by 3·7–7·2 mm, the marginal groove gradually disappearing and the hairs becoming erect and scattered as engorgement proceeds; posterolateral and median grooves well developed.

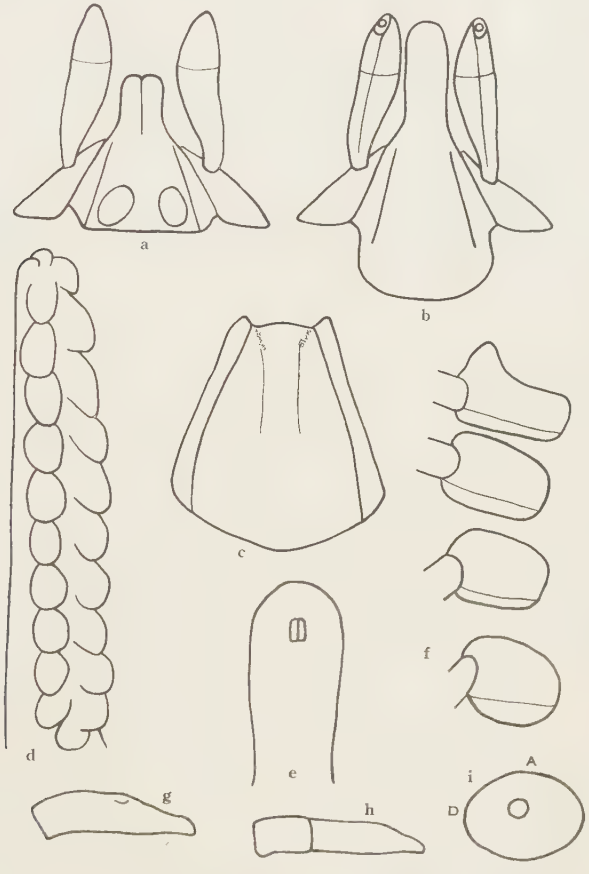

Fig. 25.—*I. fecialis*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, hypostome; *e*, anal grooves; *f*, coxae; *g*, tarsus I; *h*, tarsus IV; *i*, spiracular plate.

Capitulum.—Length 0·51–0·67 mm; basis dorsally hexagonal, 0·35–0·40 mm wide, the median field usually a little swollen and separated from the lateral fields by distinct carinae, otherwise median field flat and carinae ill defined or lacking; the posterior margin usually straight, no cornua, the posterolateral margins slightly curved, short, and divergent; basis ventrally in some specimens with similar carinae; porose areas moderate in size, oval, convergent anteriorly, sometimes not very dis-

tinct, the interval at its narrowest point about equal to the width of one; palpi flat, article 1 enlarged, triangular, inserted diagonally on basis with which it is fused but line of fusion distinct, strongly salient laterally, articles 2 and 3 about 0·48 mm in length, article 2 narrow at base, broadening medianly, article 3 as broad as article 2 but not quite half as long.

Hypostome 0·25–0·36 mm in length, with parallel sides and rounded apex; dentition 2/2 of about 10 blunt teeth, the external teeth a little larger than the internal teeth.

Scutum.—Longer than wide, 1·2–1·4 mm by 0·9–1·2 mm, widest towards the posterior margin; anterolateral margins straight or slightly sinuous, posterior angle very broad and rounded; lateral carinae well developed, straight or slightly sinuous, and a little convergent just prior to attaining the posterolateral margin; punctations sometimes few but usually numerous and fine with a few coarser areas, though sparse, laterally; cervical grooves represented anteriorly by short, shallow convergent finely granulated areas, sometimes more defined and subparallel posterior to mid-length; emargination moderate; scapulae bluntly pointed; some scattered, pale hairs.

Genital aperture.—At level of coxa III.

Genital grooves.—Divergent to posterior half of body, then curved and convergent; in engorged specimens they do not reach posterior margin of body.

Anal grooves.—Rounded in front, then subparallel or slightly curved convergently behind, and becoming a little divergent posteriorly.

Spiracular plate.—Oval, the longer axis transverse, 0·29 by 0·33 mm.

Legs.—Slender and of moderate length; coxae unarmed, with membranous outgrowths on posterior margins; coxa I with well developed anterior projection, all coxae with a row of hairs about mid-length; tarsi slender and tapering gradually, tarsus I about 0·5 mm in length, tarsus IV about 0·58 mm in length.

Nymph

Fig. 24, *i–l*

Diagnosis

Body with many hairs, becoming scattered on engorgement; scutum as in female; basis capituli and palpi as in female; dentition 2/2; coxae and anal grooves as in female.

Description

Body.—Unfed specimen 1·4 by 0·9 mm, engorged specimen 2·8 by 1·9 mm; body in unfed specimens oval, narrowly rounded posteriorly; many pale hairs becoming scattered on engorgement.

Capitulum.—Length about 0·33 mm; basis dorsally as in female with well-defined carinae, surface granulated; palpi as in female, articles 2 and 3 0·23 mm in length, article 3 not quite as long as article 2.

Hypostome 0·17 mm in length, with a bluntly rounded apex; dentition 2/2, 1/1 basally, with 9–10 teeth, the external teeth larger than the internal teeth.

Scutum.—Measurements 0·66–0·70 mm by 0·60–0·64 mm; shape and lateral carinae as in female; punctations fine and not obvious, surface granulated; cervical grooves superficial posteriorly and attaining posterolateral margin; emargination relatively shallow; scapulae rounded.

Anal grooves.—As in female.

Spiracular plate.—Oval, the longer axis transverse, 0·10 by 0·14 mm.

Legs.—As in female; tarsus I 0·28 mm in length, tarsus IV 0·3 mm long.

Hosts and Distribution

Warburton and Nuttall (1909) described this species from the western native cat, *Dasyurinus geoffroyii*, Cranbrook, W.A., March 1910, and recorded as other hosts under *I. fecialis aegrifossus*, *Isoodon obesulus*, Bannister, W.A., 21.viii.1900, and "opossum", Tamborine, Qld., June 1907. Nuttall (1916) added *Dasyurus quoll* (= *D. viverrinus*), 21.i.1912 and 4.vii.1912, and *Rattus rattus*, both records being from Sydney. Taylor and Murray (1946) included *Mus* sp., Western Australia.

Material examined.—QUEENSLAND: *Antechinus flavipes*, Dalveen, 26.vi.1951, 1 ♂, 1 ♀; *Rattus assimilis*, Mt. Glorious, 1 o; *R. conatus*, Mt. Glorious, 1 o; *I. obesulus*, Brisbane, 2 oo; "wallaby", Deception Bay, 5 ♀♀; *Felis catus*, Brisbane, 15.iii.1951, 1 ♀; *R. calmorum*, Benarkin, 22.x.1953, 3 oo; *Perameles* sp., Eidsvold, 1.vii.1890, 1 ♀. NEW SOUTH WALES: *R. assimilis*, Colo Vale, 1 o. TASMANIA: "tiger cat", Arthur R., 13.v.1951, 1 ♀; *Antechinus* sp., McIntyre R., 1 ♀, 1 o. WESTERN AUSTRALIA: *D. geoffroyii*, Mahogany Creek, 1 o; *I. obesulus*, Mahogany Creek, 2 ♀♀, *D. geoffroyii*, Kendenup, 15.i.1929, 2 ♀♀, 2 oo; *Myrmecobius fasciatus*, Tackalarap, 2 oo; *Sminthopsis crassicaudata*, Ravensthorpe, 1 ♀.

Comments

Warburton and Nuttall (1909) refer to the shape of the basis as "with wing-like projections hollowed dorsolaterally to receive the palps." These wing-like projections are the lateral extensions of palpal article 1, which is fused with the basis, although the line of fusion is distinct.

The male is described for the first time, the description being based on a single specimen. This sex is a very small tick closely resembling *I. antechinus* in shape, but is a little larger with differences in the basis capituli, the shape of the ventral plates, and in coxa I which bears a small external spur in *I. antechini*.

The nymph has also not been previously described in any detail. It was seen by Nuttall (1916) who noted that it "closely resembled the female".

The shape of palpal article 1 and of the scutum with its lateral carinae readily distinguish the female.

IXODES ANTECHINI, sp. nov.

Larva.—Unknown.

Holotype.—Male from Narrabeen, N.S.W., 5.viii.1958 (B. Marlow), in Australian Museum, Sydney. Host: *Antechinus flavipes*.

Allotype.—Female, partly engorged, same data, in Australian Museum, Sydney.

Paratypes.—Female (partly engorged), Narrabeen, N.S.W., 5.viii.1958 (B. Marlow), *A. flavipes*; female (engorged), same data; female (partly engorged), Galston Gorge, N.S.W., 27.vii.1958 (R. Mackay), *A. flavipes*; female (partly engorged), Lake George, N.S.W., 2.x.1956 (C.M.S.), *Sminthopsis murina*; female (partly engorged), same data as previous paratype. Paratypes with the exception of the females from *S. murina*, which are in the author's collection, are in the Australian Museum.

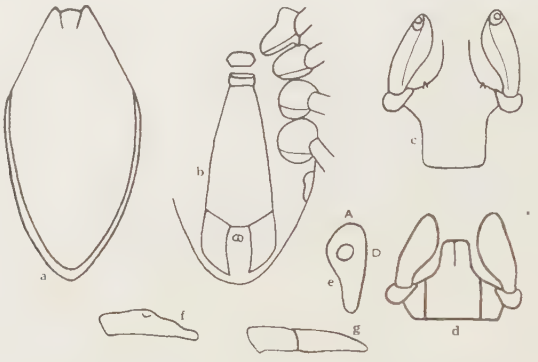

Fig. 26.—*I. antechini*, male: *a*, body (dorsal view); *b*, body (ventral view); *c*, capitulum (ventral view); *d*, capitulum (dorsal view); *e*, spiracular plate; *f*, tarsus I; *g*, tarsus IV.

Male

Fig. 26, *a–g*

Diagnosis

A very small, narrowly oval tick, pointed behind; capitulum short, basis dorsally with carinae and ventrally with a small stout spine near insertion of palpal article 1; palpi short; hypostome dentition 2/2; scutum with numerous coarse punctations and decumbent hairs; anal plate almost rectangular; all coxae with conspicuous, membranous outgrowths, coxa I with inconspicuous external spur, coxae II–IV unarmed.

Description

Body.—Very small, 1·44 by 0·74 mm, narrowly oval, widest at about mid-length, and bluntly pointed behind; marginal fold narrow, commencing about level of coxa III and broadening a little posteriorly; numerous decumbent, pale hairs.

Capitulum.—Length 0·37 mm; basis dorsally 0·30 mm wide, median field flat, finely granulated, separated from the smooth and somewhat swollen lateral fields by straight, parallel carinae extending anteriorly from the posterolateral angles; the posterior margin straight, the posterolateral margins straight and divergent anteriorly, no cornua; basis ventrally with posterior margin almost straight, the area between the insertion of the palpi swollen, a small stout spine near the internal insertion of palpal article 1; palpi wide apart, article 1 somewhat enlarged, rounded and salient laterally, triangular in shape and apparently fused with basis,

but line of fusion visible, articles 2 and 3 with suture not apparent, 0·23 mm in length, narrow basally, and widening distally, the width at mid-length not quite as wide as half the length.

Hypostome damaged, but apparently short and broad; dentition 2/2.

Scutum.—Shape similar to that of body, 1·38 by 0·72 mm, convex, no lateral carinae; punctations relatively numerous, many coarse and frequently confluent; cervical grooves short and shallow; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of coxa II.

Ventral plates.—Pregenital plate wider than long, hexagonal; median plate 0·66 mm long, more than twice as long as wide, the sides straight and divergent; anal plate somewhat rectangular, the anterior margin straight, the lateral margins gently curving and a little convergent posteriorly, 0·30 by 0·14 mm; adanal plates curving to a point posteriorly where they terminate at the posterolateral corners of the anal plate; plates with many fine punctations and hairs.

Spiracular plate.—Egg-shaped, the longer axis directed anteriorly, 0·15 mm in length, the macula anterior to centre.

Legs.—Of moderate length, the hairs stouter than on body; coxae flat, granulated, contiguous, all with well-developed, membranous outgrowths, coxa I with a stout anterior prolongation and a small, inconspicuous, external spur, coxae II–IV unarmed; tarsi tapering gradually, tarsus I 0·26 mm in length, tarsus IV 0·37 mm in length.

Female

Fig. 27, *a–g*

Diagnosis

A medium-sized comparatively slender tick, the capitulum relatively long and slender, article 1 of palpi enlarged, somewhat rectangular, its insertion almost at right angles to the transverse axis of basis, salient to a point laterally, basis dorsally with carinae; hypostome (broken) apparently slender and lanceolate, dentition 2/2; scutum much longer than broad with lateral carinae; anal grooves convergent posteriorly but wide apart; coxae as in male.

Description

Body.—Partly engorged, 6·0 by 3·4 mm; oval, widest in region of spiracles; marginal grooves indistinct; posterolateral and median grooves well defined; numerous, small, pale hairs.

Capitulum.—Relatively long and slender, 0·64 mm in length; basis dorsally 0·27 mm wide, the median field flat with fine granulations and sharply defined from the somewhat swollen lateral fields by carinae extending anteriorly towards base of mouthparts from the posteroexternal angles; posterior margin straight, posterolateral margins short, straight, divergent anteriorly, no cornua; porose areas not very clearly defined, small and oval, the interval about the width of one; basis ventrally with posterior margin rounded, no auriculae; palpi slender, article 1 enlar-

ged, fused with basis but the line of fusion visible and almost at right angles to the transverse axis of basis, somewhat rectangular and longer than broad, the posterior margin salient laterally to a small point and ventrally overlapping the anterior projection of coxa I; articles 2 and 3 0·5 mm long, the external border straight, the internal border convex, widest towards mid-length, article 3 not quite half the length of article 2.

Hypostome damaged, but appears slender, lanceolate; dentition 2/2.

Scutum.—Much longer than wide, 1·07 by 0·66 mm, and widest posteriorly, convex, lateral carinae well defined and attaining posterolateral margins; anterolateral margins practically straight, posterolateral margins short, convex, posterior

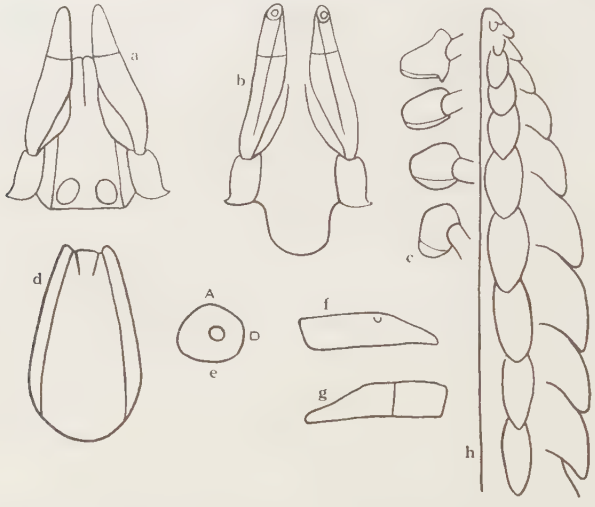

Fig. 27.—*I. antechini*, female (*a–g*) and nymph (*h*): *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, coxae; *d*, scutum; *e*, spiracular plate; *f*, tarsus I; *g*, tarsus IV; *h*, hypostome.

angle very broad and rounded; anterior median field granulated, punctations fine, scattered; cervical grooves inconspicuous, short, very shallow, convergent; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of coxa III.

Genital grooves.—Slightly divergent to about level of anus, then indistinct and convergent.

Anal grooves.—Indistinct anteriorly, then curved and convergent, but wide apart, posteriorly.

Spiracular plate.—Very small and almost circular, 0·14 mm in diameter.

Legs.—Slender, comparatively short, hairs stouter than on body; coxae flat, finely granulated, the posterior margins with membranous outgrowths, anterior prolongation of coxa I visible dorsally, coxa I with a small, blunt, external spur,

coxae II–IV unarmed; tarsi tapering gradually, tarsus I 0·35 mm long, tarsus IV 0·34 mm long.

Nymph

Fig. 27, *h*

Diagnosis

Capitulum as in female, hypostome slender and pointed, dentition 2/2; scutum as in female; coxa I with small, external spur, coxae II–IV unarmed.

Description

Body.—Partly engorged, elongate oval and bluntly pointed posteriorly, 2·1 by 1·1 mm; some scattered long, pale hairs, most numerous laterally and posteriorly.

Capitulum.—0·35 mm in length; basis dorsally 0·18 mm wide, surface granulated, carinae present; palpi as in female, article 1 0·06 by 0·03 mm, articles 2 and 3 0·27 by 0·06 mm; basis ventrally as in female.

Hypostome slender and pointed, 0·14 mm in length, dentition 2/2 of about 10 teeth.

Scutum.—Shape as in female, 0·64 by 0·43 mm, surface granulated, punctations fine and scattered, carinae well defined; emargination relatively shallow, scapulae blunt.

Anal grooves.—Rounded but not well defined anteriorly, curving gently convergently posteriorly and remaining wide apart.

Spiracular plate.—Oval, the longer axis transverse, 0·09 by 0·11 mm.

Legs.—Slender; coxae flat, surface granulated, coxa I with well-developed anterior prolongation and small, blunt, external spur, coxae II–IV unarmed; tarsi tapering gradually, tarsi I and IV 0·3 mm in length.

Comments

In the paratype females the hypostome is also damaged. They are similar to the allotype, their scuta measuring up to 1·1 by 0·7 mm. This species differs from other species of Australian *Exopalpiger* in the possession of a spur on coxa I in both sexes, and in the form of the hypostome. The shape of the scutum recalls that of *I. fecialis*, but is more elongate in comparison to its width. The shape of palpal article 1 is characteristic.

The data attached to the nymph was "*Antechinus flavipes*, New South Wales, B. McMillan."

Ixodes vestitus Neumann

Ixodes vestitus Neumann, 1908, p. 7, figs. 22, 23. Nuttall and Warburton, 1911, pp. 252–5, figs. 250–3. Ferguson, 1925, p. 28. Fielding, 1926, pp. 46–8, fig. 15. Taylor and Murray, 1946, pp. 58–60, figs. 60–2.

The male of this species is unknown.

Female

Fig. 28, *a–h*

Diagnosis

Body with many pale hairs; scutum cordiform, with lateral carinae and with few punctations except laterally; cervical grooves as broad, shallow depressions obsolete anteriorly and posteriorly; basis capituli with carinae, porose areas large, transversely oval; no cornua; no distinct auriculae; article 1 of palpi enlarged,

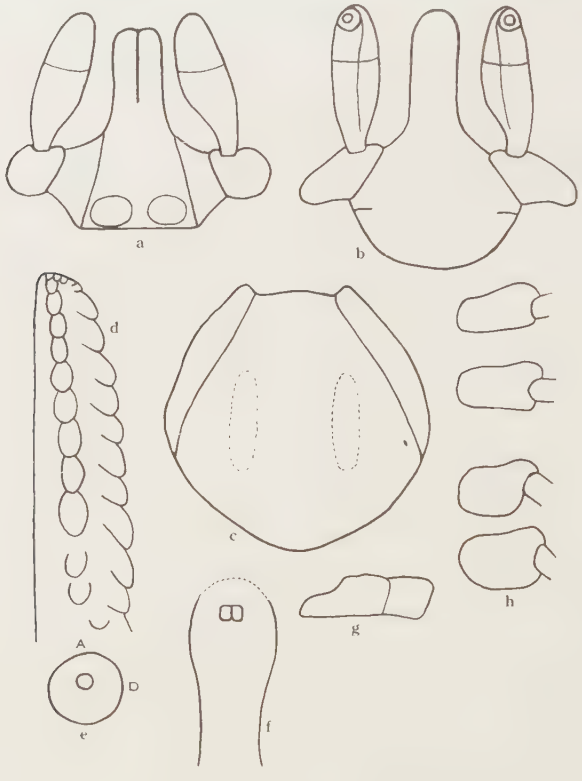

Fig. 28.—*I. vestitus*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, hypostome; *e*, spiracular plate; *f*, anal grooves; *g*, tarsus IV; *h*, coxae.

broad, somewhat discoidal and salient laterally, its insertion with basis diagonal; dentition 2/2; anal grooves subparallel posteriorly; legs stout, coxae unarmed, tarsi with subterminal humps.

Description

Body.—Semi-engorged specimen broadly oval, 6·3 by 5·1 mm, widest about midway between anus and spiracles; median and posterolateral grooves well defined; numerous, short, pale hairs, fairly evenly distributed but absent from genital grooves and from the area enclosed by anal grooves.

Capitulum.—Length 0·71 mm; basis dorsally, 0·49 mm wide, the median field flat, the lateral fields raised and delimited internally by carinae; posterior margin straight, the posterolateral angles slightly raised and rounded, but no cornua, the posterolateral margins curved and divergent anteriorly; porose areas slightly depressed, large, broadly and transversely oval, the interval somewhat raised and very narrow; basis ventrally rounded posteriorly, no distinct auriculae but with shallow ridges; palpi with article 1 inserted diagonally on and fused with basis, but line of fusion visible, enlarged, somewhat discoidal, and strongly salient laterally, ventrally article 1 appears triangular; article 2 narrow at base broadening distally, article 3 distinct from article 2, as broad but only half as long, articles 2 and 3 0·43 mm in length.

Hypostome with parallel sides and rounded distally; dentition 2/2 of about 8–10 teeth, the inner file well separated from the external file.

Scutum.—Cordiform and convex, about as long as wide, 1·30 by 1·32 mm, and widest just anterior to mid-length; anterolateral and posterolateral margins convex, lateral and posterior angles broadly rounded; lateral carinae fine but distinct, extending to posterolateral margins; surface glossy; punctations fine and sparse medianly, more numerous and relatively coarser laterally; cervical grooves represented by short, wide, and shallow depressions obsolete anteriorly and posteriorly and located midway between centre and lateral margins; emargination moderate; scapulae bluntly pointed.

Genital aperture.—In second intercoxal space.

Genital grooves.—Deep, straight, and divergent, but curving convergently just prior to meeting the posterior margin of the body.

Anal grooves.—Indistinct anteriorly, wide apart and subparallel posteriorly.

Spiracular plate.—Subcircular, small, 0·21 mm wide, the macula anterior to centre.

Legs.—Short but relatively stout; coxae unarmed, the surface convex and glossy, posterior margin trenchant, anterior prolongation of coxa I hidden by palpal article 1 ventrally but visible dorsally; tarsi with short subapical humps, tarsus IV 0·24 mm long (leg 1 missing).

Nymph and Larva

The following descriptions are taken from Nuttall and Warburton (1911):

"Nymph: resembles the ♀ except in the shape of the scutum, which is of the *fecialis* type, being broadest near its posterior extremity. The dorsum is thickly clothed with strong white hairs."

"Larva: resembles the ♂. Four longitudinal rows of white hairs on the dorsum."

Hosts and Distribution

I. vestitus was described by Neumann (1908) from a female taken from the marsupial ant-eater, *Myrmecobius fasciatus*, from Western Australia, and Nuttall and Warburton (1911) recorded a female, nymph, and larvae from the brown snake

Demansia textilis (*Diemenia superciliosa*) from Herdman's Lake, near Perth. According to Calaby (personal communication), this is the species usually found on *Myrmecobius* in this State.

Comments

The above description of the female was taken from the specimen recorded by Nuttall and Warburton (1911) from *D. textilis* and kindly made available by Dr. G. Owen Evans, British Museum (Natural History), and agrees very closely with that given by these workers. Only two Australian species are recorded from Reptilia, namely *I. vestitus* and *I. ornithorhynchi*.

The female *I. vestitus* is a distinctive tick and can be readily determined from other Australian species with unarmed coxae occurring on animals by the cordiform scutum and its cervical grooves, the appearance of palpal article 1, and the short humped tarsi.

Ixodes holocyclus Neumann

Ixodes holocyclus Neumann, 1899, pp. 151–5, figs. 24–6; 1901, p. 249. Rainbow, 1906, p. 167. Nuttall and Warburton, 1911, pp. 235–8, figs. 230–2. Ross, 1924, pp. 365–81, figs. 1 and 2, pl. 15, figs. 1–18. Ferguson, 1925, pp. 27–8. Fielding, 1926, pp. 39, 40, fig. 10. Sharif, 1928, pp. 230, 232–3. Krijgsman and Ponto, 1932, pp. 27–8, figs. 43–4. Taylor and Murray, 1946, pp. 48–52, figs. 51–3. Seddon, 1951, pp. 119–33, with figure showing distribution. Roberts, 1959, p. 268 (see also Roberts, 1954, p. 144).

Not *Ixodes holocyclus*. Schulze, 1935, pp. 34–6, fig. 5.

Ixodes (*Sternalixodes*) *rossianus* Schulze, 1935, p. 36.

Sternalixodes rossianus Arthur, 1956*b*, p. 272.

Male

Fig. 29, *a–h*

Diagnosis

Body measurements less than 3·0 by 2·5 mm; lateral grooves completely encircling scutum, no lateral carinae; punctations fine; basis capituli punctate dorsally, palpi short and very broad; hypostome dentition 2/2, with rounded teeth; anal plate bluntly pointed behind; adanal plate curving inwardly to a point; coxae with well-defined external spurs decreasing in size posteriorly; trochanters III and IV frequently with small, ventral spurs.

Description

Body.—Oval, widest at about mid-length, and broadly rounded posteriorly, 1·9–2·8 mm by 1·6–2·1 mm; marginal body fold narrow; hairs few and scattered, most numerous in region of marginal body fold.

Capitulum.—Short, 0·51–0·60 mm in length; basis dorsally 0·4 mm wide, surface punctate, posterior margin straight, posterolateral margins straight, slightly divergent anteriorly, no cornua; palpi short and very broad, article 1 wider than long, rounded, and a little salient laterally, ventrally with an erect semicircular flange, which is continuous with a short ridge on basis, articles 2 and 3 apparently fused, 0·33 mm in length, widest medianly and about twice as long as wide.

Hypostome short and broad, rounded apically, about 0·25 mm in length; dentition 2/2 of about 5 rounded teeth, decreasing in size basally, where the teeth appear as fine crenulations, a few small denticles apically.

Scutum.—Convex, glossy, measurements only a little less than those of body; lateral grooves deep and completely encircling the scutum; punctations fine, scattered, usually most numerous anteriorly and laterally, pseudoscutum sometimes faintly visible; no lateral carinae; cervical grooves short, shallow, convergent; emargination moderate; scapulae bluntly pointed.

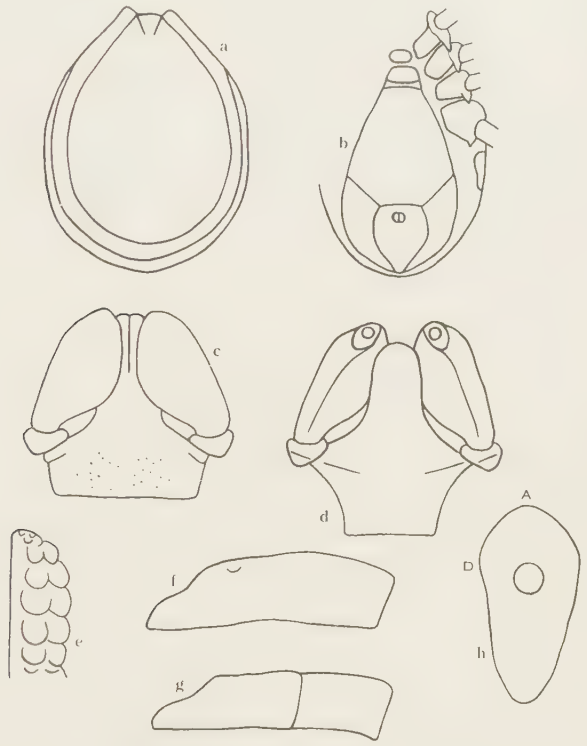

Fig. 29.—*I. holocyclus*, male: *a*, body (dorsal view); *b*, body (ventral view); *c*, capitulum (dorsal view); *d*, capitulum (ventral view); *e*, hypostome; *f*, tarsus I; *g*, tarsus IV; *h*, spiracular plate.

Genital aperture.—At level of anterior margin of coxa III, sometimes in second intercoxal space.

Ventral plates.—Pregenital plate hexagonal and wider than long; median plate very broad posteriorly where the width is about three-quarters the length; anal plate with anterior margin straight or slightly convex, the sides curved, bluntly pointed behind; adanal plates curving posteriorly to points which meet or almost meet behind the point of the anal plate; plates almost impunctate, with some short, pale hairs.

Spiracular plate.—Elongate oval, the longer axis directed anteriorly, about 0·5 mm in length and about twice as long as wide.

Legs.—Of moderate length; coxae contiguous, flat, the posterointernal angles, especially of coxae I III, somewhat sharp, with well-developed, external, blunt spurs decreasing in size posteriorly, and a row of long, pale hairs near the posterior margin; trochanters III and IV frequently with small, pointed, ventral spurs, at most tuberosities on trochanters I and II; tarsi tapering gradually, particularly tarsus I, tarsus I 0·65–0·67 mm in length, tarsus IV 0·62–0·64 mm in length.

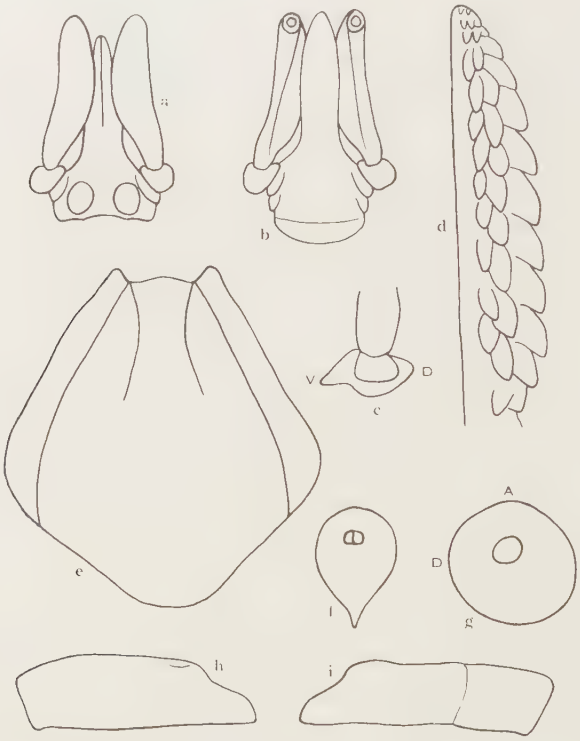

Fig. 30.—*I. holocyclus*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, palpal article 1 (lateral view); *d*, hypostome; *e*, scutum; *f*, anal grooves; *g*, spiracular plate; *h*, tarsus I; *i*, tarsus IV.

Female

Fig. 30, *a–i*

Diagnosis

A very large tick when fully engorged; scutum about as long as broad and broadest a little posterior to mid-length, with strong, lateral carinae; capitulum relatively long, porose areas deep, cornua usually absent, but when present at most only mild and rounded; auriculae present; hypostome lanceolate, dentition mainly 3/3; no sternal plate; anal grooves meeting at a point behind; all coxae with an

external spur decreasing in size posteriorly: trochanters III and IV usually with small, pointed ventral spurs.

Description

Body.—Unfed specimens with flat, oval body, widest posteriorly, 2·6–3·8 mm by 1·1–2·6 mm; marginal grooves well developed, complete; some pale, scattered hairs most numerous in region of marginal fold; body in semi-engorged specimens frequently widest just behind coxa IV and with a "waist" at level of spiracles; engorged specimens broadly oval, measuring up to 13·2 by 10·2 mm, living ticks with blue-grey body, the dorsum lighter in colour and limited by a dark band which represents the marginal grooves.

Capitulum.—Long, 1·00–1·25 mm in length; basis dorsally about 0·64 mm wide, the lateral fields swollen and occasionally clearly demarked from the depressed median field, posterior margin sinuous, occasionally with shallow, rounded, raised cornua, posterolateral margins a little divergent anteriorly; porose areas large, circular or broadly oval, deep, almost contiguous with posterior margin of basis, the interval frequently depressed and usually not equal to the width of one; basis ventrally with posterior margin a little convex, with faint sutural line, and with well-developed blunt auriculae; palpi long, article 1 rounded and salient laterally, ventrally with an erect, semicircular keel-like flange extending across the width, and sometimes also with a similar but much milder flange dorsally, articles 2 and 3 apparently fused, about 0·85 mm in length, and three times as long as wide.

Hypostome 0·71–0·76 mm in length, narrowly lanceolate and bluntly pointed, dentition with some very small denticles apically, mainly 3/3, becoming 2/2 basally, teeth in files 1 and 2 decreasing in size from mid-length both apically and basally, file 3 with very small teeth.

Scutum.—As wide as long or slightly wider than long, 1·6–2·3 mm by 1·7–2·3 mm, widest a little posterior to mid-length; flat medianly, the lateral fields convex and limited internally by strong, lateral carinae, which are straight or mildly sinuous and curved convergently to meet the posterolateral margins; anterolateral margins slightly sinuous, posterior angle broadly rounded; punctations numerous, fine medianly, frequently coarser and sometimes a little rugose laterally, fine rugae may also be present along the posterior margin; cervical grooves fairly well defined, convergent, and then continuing a short distance posteriorly as very superficial and divergent depressions; emargination moderate; scapulae blunt.

Genital aperture.—In third intercoxal space, or at the level of coxa IV, or sometimes in engorged specimens immediately posterior to level of coxa IV.

Genital grooves.—Divergent to about level of anus, then curving convergently.

Anal grooves.—Convex anteriorly, curving convergently behind to meet in a somewhat elongate point.

Spiracular plate.—Moderate in size, subcircular, about 0·4 mm in diameter.

Legs.—Similar to those of the male, the coxae separating as engorgement proceeds; trochanters III and IV ventrally, frequently with an inconspicuous,

pointed external spur; tarsi tapering gradually, tarsus I 0·70–0·78 mm in length, tarsus IV 0·69–0·70 mm in length.

Nymph

Fig. 31, *a–i*

Diagnosis

Capitulum as in female, hypostome dentition mainly 2/2, 3/3 distally; scutum about as long as wide with lateral carinae; sternal plate present, oval; anal grooves converging posteriorly but remaining narrowly open; legs as in female.

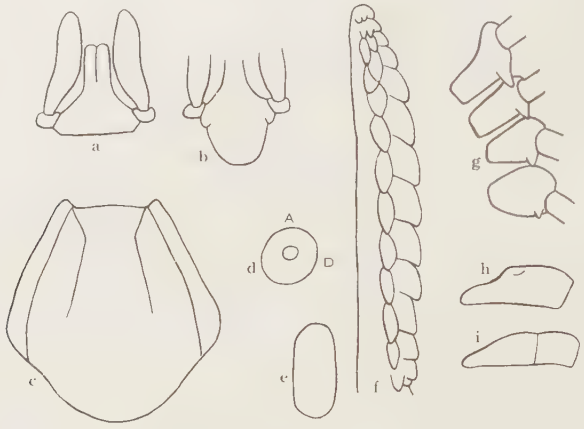

Fig. 31.—*I. holocyclus*, nymph: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, spiracular plate; *e*, sternal plate; *f*, hypostome; *g*, coxae; *h*, tarsus I; *i*, tarsus IV.

Description

Body.—Oval with fine parallel striae and some scattered, pale hairs; 1·2 by 0·85 mm (unfed) to 3·5 by 2·5 mm (engorged); marginal grooves well developed and complete in unfed specimens.

Capitulum.—About 0·43 mm in length; basis dorsally about 0·23 mm wide and wider than long, posterior margin straight, posterolateral margins slightly divergent anteriorly; palpi long and slender, article 1 rounded and somewhat salient laterally, articles 2 and 3 apparently fused, about 0·3 mm in length and about three times as long as wide; auriculae bluntly pointed and well developed.

Hypostome slender with sides gently curved and apex bluntly pointed, dentition mainly 2/2, 3/3 distally, file 3 with about 4 small, blunt teeth, files 1 and 2 with about 12 pointed, well-developed teeth.

Scutum.—About as long as wide, 0·61–0·71 mm by 0·63–0·70 mm, widest a little posterior to mid-length, with lateral carinae; anterolateral margins a little sinuous, posterior angle broadly rounded; punctations fine, not obvious, lateral

fields finely granulated; cervical grooves well defined, short, and convergent, then diverging as shallow depressions to about mid-scutal length; emargination moderate; scapulae blunt.

Sternal plate.—Oval, narrowing a little anteriorly, 0·30 by 0·14 mm.

Anal grooves.—Sometimes ill defined anteriorly, curving and convergent posteriorly, not quite meeting in unengorged specimens, and becoming more apart as engorgement proceeds.

Spiracular plate.—Subcircular, at level with anus, 0·14 mm in diameter.

Legs.—As in female.

Larva

Fig. 32, *a–f*

Diagnosis

Capitulum with slender palpi, hypostome rounded apically, dentition 2/2; scutum about as long as wide, with faint lateral carinae; all coxae with small, external spurs.

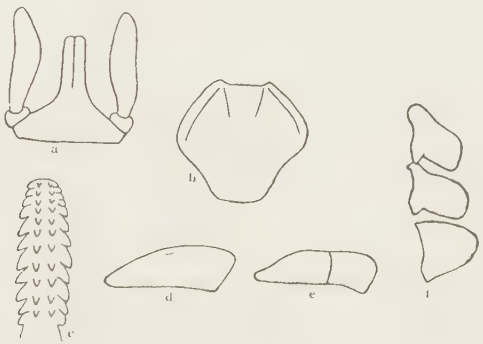

Fig. 32.—*I. holocyclus*, larva: *a*, capitulum (dorsal view); *b*, scutum; *c*, hypostome; *d*, tarsus I; *e*, tarsus IV; *f*, coxae.

Description

Body.—Broadly oval, 0·5 by 0·4 mm (unfed) to 1·15 by 1·0 mm (engorged).

Capitulum.—About 0·2 mm in length, basis triangular, about 0·16 mm wide, palpi elongate and slender.

Hypostome apically rounded, 0·14 mm in length, dentition 2/2 of 10-12 teeth, the teeth of the inner file blunt and small, some minute denticles apically.

Scutum.—About as long as broad, 0·31 by 0·32 mm and widest a little anterior to mid-length, lateral carinae present but faint; anterolateral margins usually convex and posterolateral margins concave; cervical grooves short but well defined.

Anal grooves.—Ill defined anteriorly and do not converge behind.

Legs.—Coxae with small external spurs; tarsus I 0·14 mm in length, tarsus IV 0·14 mm in length.

Hosts and Distribution

Ticks under the name *I. holocyclus* Neumann, 1899, have been recorded from India, Kei I., Indonesia, and from New Guinea as well as from Australia. The record from India by Neumann (1899) was based on three nymphs, one mounted on a slide, the hosts being noted as *Sciuris variabilis* and "ecureuil rouge". Sharif (1928), in his revision of Indian Ixodidae, included this species in his key to the species of *Ixodes*, but made no other mention of it. Apparently its inclusion in his paper was based on Neumann's record. The Indonesian record by Krijgsman and Ponto (1932) also refers to a nymph. *I. holocyclus*, however, is not included by Anastos (1950) in his list of the scutate ticks of this area. The New Guinea record comes from roneod reports (1953, 1954) issued by the Department of Agriculture, Stock, and Fisheries, Port Moresby. In view of the fact that there are several species all superficially similar to *I. holocyclus*, the nymphs of some of which have not been described, all the above records are regarded as doubtful. This is particularly so for New Guinea with its *I. cordifer* of Neumann (1908), *I. cordifer cordifer* and *I. cordifer bibax* of Schulze (1935), and *I. confusus* (see p. 464), and from where no case of tick paralysis, as might be expected were *I. holocyclus* to occur there, has been recorded.

Seddon (1951) gives the distribution of *I. holocyclus* in Australia as follows:

"This tick is confined to the coastal areas along the northern and eastern coasts of Queensland and New South Wales, part of Victoria and Tasmania and is restricted to brush and scrub country. For the most part it occurs only within a few miles of the coast, but in southern Queensland and northern New South Wales it extends somewhat further inland. Thus in Queensland it is present in all coastal areas and also in the Burnett, as far west as the Bunya Mountains, in the whole of the Brisbane watershed, and also at Warwick.

In New South Wales likewise it is most prevalent along the coast, especially in the Macleay and Kempsey districts and around Sydney, but on the far north coast extends inland as far as the valleys leading into the Dividing Range . . . . Around Sydney it is especially common in the area between Port Jackson and the Hawkesbury River . . . . Quite recently this tick has made its appearance on the Western side of the George's River, at Glenfield.

In eastern Victoria this tick is present along the coast as far as Lakes Entrance and in Tasmania it is confined to the east coast and Hobart . . . . In 1945, this tick was found in Melbourne, the infested dog dying from tick paralysis."

In the extensive material available to the author the most southern locality from which *I. holocyclus* was collected was Bairnsdale, near Lakes Entrance, on the east coast of Victoria. Several specimens seen from this locality were taken from dogs affected with tick paralysis.

No specimens of this species were seen from Tasmania, but enquiries confirmed Seddon's (1951) report of the occurrence of tick paralysis in this State. *I. cornuatus* is present in Tasmania, and as there is a single record of the association of this species with paralysis (see p. 469) the reference by Seddon (1951) to *I. holocyclus* in Tasmania could refer to *I. cornuatus*. *I. hirsti* also occurs in Tasmania and the role of this species in tick paralysis is unknown.

I. holocyclus has also been collected from Armidale, N.S.W., a locality not included in Seddon's distribution records.

I. holocyclus has been recorded by Nuttall and Warburton (1911) also from Western Australia, the records being based on two females from "*Macropus* sp."

and on two nymphs from an unknown host. It was not represented in the material from this State seen by the author* and there are no records of tick paralysis from this part of Australia.

The host list of *I. holocyclus* includes all the domestic animals, the domestic fowl, domestic duck, and man. It has also been taken from the crow, *Corvus coronoides*, the wild rabbit, *Oryctolagus cuniculus*, and from *Wallabia bicolor*, *Isoodon obesulus*, *I. torosus*, *Perameles nasuta*, *Trichosurus vulpecula*, *Phascolarctos cinereus*, *Antechinus flavipes*, *Phascogale tapoatafa*, *Dendrolagus lumholtzi*, *Rattus rattus*, *R. assimilis*, *R. norvegicus*, *R. cornatus*, *Hydromys chrysogaster*, *Melomys littoralis*, *M. cervinipes*, *Uromys caudimaculatus*, and *Canis dingo*. The host range is undoubtedly more extensive than this list, as many of the legends accompanying specimens referred only to the host's popular name, e.g. wallaby, kangaroo, rat, bandicoot, etc., or only to the genus, e.g. *Wallabia* sp., *Macropus* sp., *Rattus* sp., etc. *I. holocyclus* has been successfully bred on small laboratory animals (rabbit, guinea pig, and mouse). Nuttall (1916) recorded it from a monkey at the Zoological Gardens, Sydney, and Ferguson (1925) from *Pitta* sp., one of the dragoon birds.

As regards seasonal prevalence of the various stages in the life cycle, Seddon (1951) notes that tick paralysis which is associated with the female, and more rarely with the nymph, is seen chiefly in the spring and summer, but in areas with favourable warm and humid conditions this disease can be seen at any time of the year. Data from the material examined indicated that while females may be found at almost any time of the year, they are most numerous from August to December, and particularly during October and November. Nymphs have been taken mainly throughout the winter and early spring, and larvae mainly in the summer and autumn.

Comments

Ross (1924), in his studies on tick paralysis in the dog, attributed this condition to *I. holocyclus* Neumann and gave a detailed description of all the life cycle stages of this tick. His description and figures agree very closely with the description published by Neumann (1899) and by Nuttall and Warburton (1911). Schulze (1935), however, considered that the species determined by Ross (1924) as *I. holocyclus* was not Neumann's *I. holocyclus* and based this opinion on an examination of a "cotype" of Neumann's in the Berlin Museum, which he figured as possessing a sternal plate. He also said that Neumann's *I. holocyclus* came from New Zealand. Schulze regarded Ross's *I. holocyclus* as a new species to which he gave the name *I. rossianus*. It would seem that Neumann's cotype seen by Schulze could be a specimen of *I. hirsti* and had been erroneously identified by Neumann as *I. holocyclus*. The locality mentioned by Schulze (1935), namely New Zealand, is also erroneous as no species of *Sternalixodes* occurs in that country (Dumbleton 1953).

Of the five species of Australian *Sternalixodes*, *I. holocyclus* is closest to *I. cornuatus*. The females of neither species possesses a sternal plate, the absence of

* Mr. J. C. Calaby (1960) has noted that female ticks from *Myrmecobius fasciatus*, *Bettongia penicillata*, Dryandra, W.A., and from *Setonix brachyuris*, Bald I., W.A., were determined as *I. holocyclus* by D. C. Swan, Waite Institute, Adelaide. These specimens were not available for examination.

which readily separates them from the females of *I. hirsti*, *I. trichosuri*, and *I. confusus*. The female *I. cornuatus* may be readily separated from *I. holocyclus* by the larger dimensions of its capitulum and scutum, by the strong, blunt cornua, and by the hypostome dentition (see Figs. 30*d* and 36*f*). The males appear almost identical morphologically, but *I. cornuatus* may be recognized by its greater size, the more abruptly terminating tarsi, and by the hypostome dentition (Table 1).

TABLE 1

COMPARISON OF DIMENSIONS OF I. HOLOCYCLUS AND I. CORNUATUS

Part Measured	*I. holocyclus*		*I. cornuatus*	
	Male (mm)	Female (mm)	Male (mm)	Female (mm)
Body	1·9–2·8 by 1·6–2·1	2·6–3·8 by 1·1–2·6*	3·5 by 2·5	4·7–4·9 by 3·3–3·7*
Capitulum, length	0·51–0·60	1·00–1·25	0·70–0·72	1·50
Capitulum, width, dorsally		0·64		0·85
Spiracular plates, length	0·50	0·40	0·71	0·53
Tarsus I	0·65–0·67	0·70–0·78	0·82	1·07
Tarsus IV	0·62–0·64	0·69–0·70	0·79	0·90
Scutum		1·6–2·3 by 1·6–2·2		2·5–2·8 by 2·3–2·4
Hypostome		0·71–0·76		0·96

* Unfed specimens.

IXODES CONFUSUS, sp. nov.

Ixodes cordifer Roberts, 1955, pp. 21–5, figs. 1 and 2; 1959, p. 268.

The nymph and larva of this species are unknown.

Holotype.—Male, Sogeri, Papua, July 1953, in the Queensland Museum. Host: "wallaby".

Allotype.—Female (partly engorged), Sogeri, Papua, 7.xii.1951 (J. Barrett), in the Queensland Museum. Host: "wallaby".

Paratypes.—1 ♂, 3 ♀♀ (partly engorged), all damaged, Sogeri, Papua, 28.i.1951 (J. Barrett), "wallaby"; 1 ♀ (partly engorged), 1 ♀ (fully engorged), same data as allotype; 2 ♀♀ (partly engorged), both damaged, same data as holotype; 3 ♀♀ (partly engorged), Sogeri, Papua, 10.xi.1951 (J. Barrett), "wallaby"; 1 ♀ (unfed), Etty Bay, N. Qld., 24.iii.1949, man. Paratypes in the collections of the Animal Research Institute and the Veterinary Parasitology Laboratory, C.S.I.R.O., Yeerongpilly, Qld.

Male

Fig. 33, *a–g*

Diagnosis

Body oval, marginal body fold very narrow; lateral grooves as mild carinae anteriorly, disappearing to be seen again posteriorly as wide, shallow depressions; capitulum short, palpi broad, hypostome dentition 2/2 with rounded teeth; genital aperture at level of coxa II; anal plate pointed behind; coxae I-III with internal and external spurs, the internal spur not conspicuous, coxa IV with a single, long, pointed spur: trochanters ventrally with spurs; tarsi tapering somewhat abruptly.

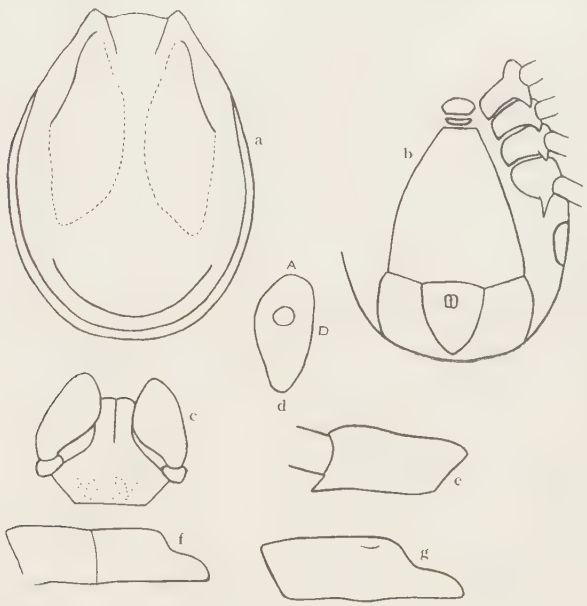

Fig. 33.—*I. confusus*, male: *a*, body (dorsal view); *b*, body (ventral view); *c*, capitulum (dorsal view); *d*, spiracular plate; *e*, trochanter IV; *f*, tarsus IV; *g*, tarsus I.

Description

Body.—Broadly oval, 2·8 by 1·8 mm, widest in region of spiracles; marginal body fold narrow; some scattered, fine, minute hairs.

Capitulum.—Short, 0·63 mm, basis dorsally 0·45 mm wide, pentagonal, surface punctate, the posterior and posterolateral margins straight, the latter divergent anteriorly, no cornua; palpi about 0·52 mm in length, article 1 a little wider than long, with a transverse, ventral flange, articles 2 and 3 apparently fused, narrow at base but broadening rapidly and attaining a width of about half the length.

Hypostome about 0·26 mm long, broad, rounded distally, dentition 2/2 of 6 rows of broadly rounded teeth, the basal rows ridge-like.

Scutum.—A smooth, broad, triangular depression on either side extending up to two-thirds the length and bounded laterally by mild lateral carinae, lateral grooves otherwise visible only posteriorly as broad, shallow depressions; punctations relatively few and fine medianly, more numerous along margins, particularly in the region of the lateral carinae; cervical grooves short and shallow, convergent; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of coxa II.

Ventral plates.—Pregenital plate wider than long; median plate 1·40 by 1·07 mm, widest posteriorly, where it is about three times as wide as anteriorly; adanal plates almost straight anteriorly, curving posteriorly with a broad fusion behind anal plate, and wider posteriorly than anteriorly; anal plate depressed, about 0·5 mm in length, about as wide as long, somewhat cordiform in shape and pointed behind.

Spiracular plate.—Oval, the longer axis directed anteriorly, narrower posteriorly than anteriorly, 0·50 by 0·22 mm.

Legs.—Length moderate; coxae broad, flat, and contiguous or almost so, a few long hairs towards the posterior margins, coxae I–III with a medium-sized external spur, the posterointernal angles sharp and forming a shallow, inconspicuous spur, both spurs most prominent on coxa I, coxa IV with a single comparatively long pointed spur; trochanters each with a single pointed spur, less conspicuous on trochanter I and increasing a little in size from trochanters II to IV; tarsi tapering somewhat abruptly, tarsi I and IV about 0·70 mm long.

Female

Fig. 34, *a–j*

Diagnosis

Partly fed specimens with broad shoulders; marginal grooves visible only laterally; scutum longer than wide, with strong lateral carinae; capitulum long, the basis both dorsally and ventrally with lateral and median carinae; porose areas oval; no cornua; auriculae present; dentition mainly 3/3; sternal plate present, elongate triangular in shape; genital aperture posterior to coxa IV; anal grooves meeting posteriorly; legs crowded anteriorly, coxae with longitudinal ridges and with external spurs; trochanters ventrally with spurs; tarsi tapering abruptly.

Description

Body.—Partly engorged, somewhat broadly cordate in shape, and distinctly widest just posterior to coxae IV, from where it narrows rapidly posteriorly, 5·0 by 3·5 mm; posterolateral and median grooves apparent; marginal grooves faintly defined and visible laterally only; hairs sparse, minute, and pale.

Capitulum.—Long, 1·5 mm; basis dorsally pentagonal, 0·7 mm wide, posterior margin slightly sinuous, a little elevated medianly, strong carinae laterally and a less-defined carina medianly, the former extending from the posteroexternal angle to the base of the mouthparts, giving the angles a swollen appearance, but there are no cornua; porose areas oval, the longer axis directed anteriorly, the interval slightly

less than the width of one; basis ventrally with 3 similar carinae, the lateral carinae terminating in auriculae; palpi elongate and very slender, 1·1 mm in length, projecting slightly beyond tip of hypostome, article 1 transverse, rounded and salient laterally, articles 2 and 3 apparently fused, widest medianly, with a maximum width of not quite one-quarter the length.

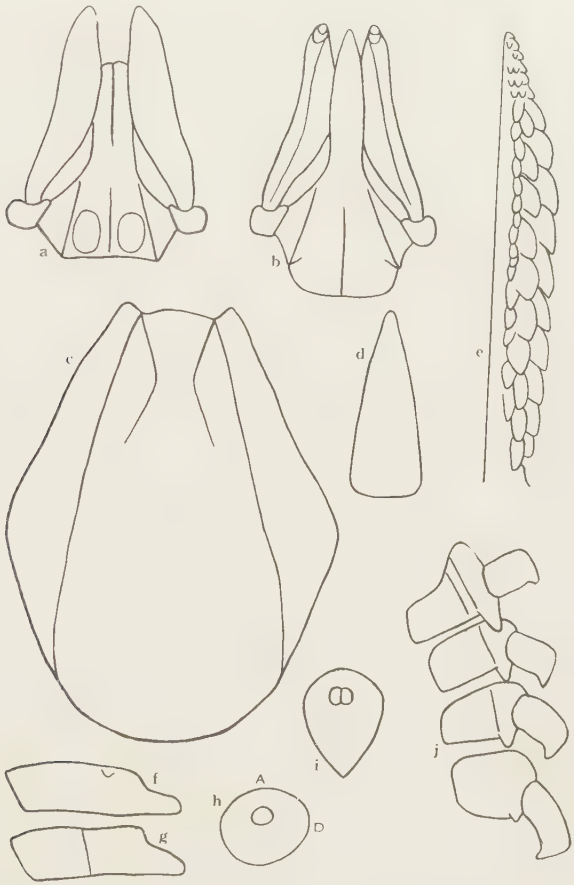

Fig. 34.—*I. confusus*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, sternal plate; *e*, hypostome; *f*, tarsus I; *g*, tarsus IV; *h*, spiracular plate; *i*, anal grooves; *j*, coxae and trochanters.

Hypostome lanceolate and pointed, 0·8 mm long; dentition mainly 3/3, file 3 consisting of a number of small, crowded teeth disappearing basally, files 1 and 2 with about 10 much larger pointed teeth.

Scutum.—Longer than wide, 2·5 by 2·0 mm, widest a little posterior to mid-length, flat medianly, convex laterally, with prominent and strong lateral carinae; anterolateral margins sinuous, posterolateral margins sinuous, posterior angle broadly rounded; punctations fine medianly, more numerous laterally; cervical grooves short, superficial; emargination moderate; scapulae blunt.

Genital aperture.—Posterior to level of coxa IV, preceded anteriorly by an elongate triangular sternal plate measuring 0·86 by 0·25 mm.

Genital grooves.—Deep for a short distance below the genital aperture and forming cavities.

Anal grooves.—Broadly pyriform and meeting at a point posteriorly.

Spiracular plate.—Subcircular, the longer axis transverse, 0·48 by 0·57 mm.

Legs.—Length moderate, crowded anteriorly; coxae narrowly separated, coxa I with 2 prominent anteriorly directed ridges, coxae II–IV each with a similar ridge, very weakly developed on coxa IV, all coxae with a row of hairs adjacent to posterior margin and a single, medium-sized external spur, decreasing in size posteriorly; trochanters ventrally with blunt spurs, less conspicuous on trochanter I; tarsi tapering somewhat abruptly, tarsus I about 0·93 mm in length, tarsus IV 0·88 mm in length.

Comments

There has been some confusion between this species and *I. cordifer* Neumann 1908 which was described from a single male from an unknown host from Sekoe, New Guinea. The specimens listed in the above description of *I. confusus* from "wallaby" hosts, Sogeri, Papua, were previously determined by Roberts (1955) as *I. cordifer* and descriptions of the male and female were published. The males from Sogeri agree very closely with Neumann's description of *I. cordifer*, but possess trochantal spurs, a character not mentioned by Neumann for his *I. cordifer*.

Schulze (1935) identified *I. cordifer* from various hosts in New Guinea, and mentioned that he had seen all stages in the life cycle. Schulze, unfortunately, did not give any description of the male and only very brief descriptions of the female and nymph. Through the courtesy of Dr. G. M. Kohls, the author was able to examine several females from Schulze's material, but no males were present. The females did not possess trochantal spurs and the sternal plate was quite different in shape to that of the species from Sogeri. Neumann's type of *I. cordifer*, which had been deposited in the Leiden Museum cannot be found, and must be regarded as lost. Whether Schulze's *I. cordifer* and Neumann's *I. cordifer* are the same species must remain undecided until such time as a male of Schulze's *cordifer* is available. It is evident, however, that the species from Sogeri determined by Roberts (1955) as *I. cordifer* is not Neumann's species and that a decision to regard it as a new species is justified.

Little-fed specimens of female *I. confusus* are oval in shape with well-defined marginal grooves which extend laterally only. As engorgement proceeds these grooves disappear and the shape of the tick becomes very characteristic, broadening rapidly anteriorly and giving the appearance of strong shoulders, thence conspicuously narrowing again between coxa IV and the spiracles. The legs in these specimens are crowded anteriorly with almost contiguous coxae. Fully engorged females are normal in appearance being broadly oval and measuring up to 11·2 by 8·6 mm. Mention is made in the description of the allotype of the presence of 3 carinae both dorsally and ventrally on the basis capituli. In the allotype the median dorsal carina is much less developed than the lateral carinae, but in the female paratypes

it is almost as strongly defined. The presence of *I. confusus* in Australia is based on a record of a single female taken from man from Etty Bay, N. Qld., and listed above as a paratype.

Of the Australian species of *Sternalixodes*, *I. confusus* is closest to *I. hirsti*. The differences between the two species are discussed under *I. hirsti*.

Ixodes cornuatus, sp. nov.

Ixodes holocyclus Roberts, 1954, p. 144.
Ixodes cornuata Roberts, 1959, p. 268.

The nymph and larva of this species are unknown.

Holotype.—Male, Cox's Bight, Tas., April 1940, (C. D. King), in the National Museum, Melbourne. Host unknown.

Allotype.—Female (partly engorged), Victoria, 17.iv.1953 (J. Membrey), in the National Museum, Melbourne. Host: *Canis familiaris.*

Paratypes.—Male (mounted), Warragul district, Vic., February 1958, host unknown; unfed female (mounted), Noojee, Neerim North, Vic., 9.vii.1908, (T. G. Robinson), "kangaroo"; engorged female, Lakes Entrance, Vic., October 1919 (F. E. Wilson), *Canis familaris* (paralysis); engorged female, Lakes Entrance, 12.ii.1958 (K. Gotchie), host unknown; unfed female, Lakes Entrance, 30.iii.1956, host unknown; partly fed female, Broulee, N.S.W., 22.i.1949, host *Felis catus*; unfed female, Cox's Bight, June 1939 (D. King), host unknown; semi-engorged female, Gordon R., Tas., January 1949 (Capt. Sutton), host unknown. The paratypes from Warragul, Noojee, Broulee, and from *C. familiaris*, October 1919, Lakes Entrance, are in the collection of the Veterinary Parasitology Laboratory, C.S.I.R.O., Yeerongpilly, Qld., those from unknown hosts, Lakes Entrance, 12.ii.1958 and 30.iii.1956, and from Gordon R. are in the National Museum, Melbourne; that from Cox's Bight is in the Tasmanian Museum, Hobart.

Male

Fig. 35, *a–h*

Diagnosis

A relatively large tick, lateral grooves well defined and completely encircling the scutum, punctations fine, no lateral carinae; capitulum short, the basis punctate dorsally, no cornua, palpi short and very broad, article 1 with a well-developed, erect, keel-like flange ventrally; anal plate bluntly pointed behind; coxae with an external spur, trochanters with an external tuberosity; tarsi terminating a little abruptly.

Description

Body.—Broadly oval, 4·4 by 2·8 mm, widest in region of spiracles; marginal body fold commencing at level of coxa III, narrow; hairs relatively few dorsally, more numerous ventrally.

Capitulum.—Short, 0·7 mm in length; basis dorsally 0·64 mm wide, surface punctate, posterior margin straight, posterolateral margins straight and divergent anteriorly, no cornua; basis ventrally with the posterior margin almost straight,

palpi short, flat, very broad, article 1 wider than long, rounded and salient laterally, ventrally with an erect, keel-like flange in line with ridges on the basis, articles 2 and 3 apparently fused, widest medianly and not quite half as wide as long.

Hypostome short and broad, about 0·34 mm in length; dentition 2/2 of about 5 rows of rounded teeth, the external file larger than the internal file, followed by 2 rows of crenulations.

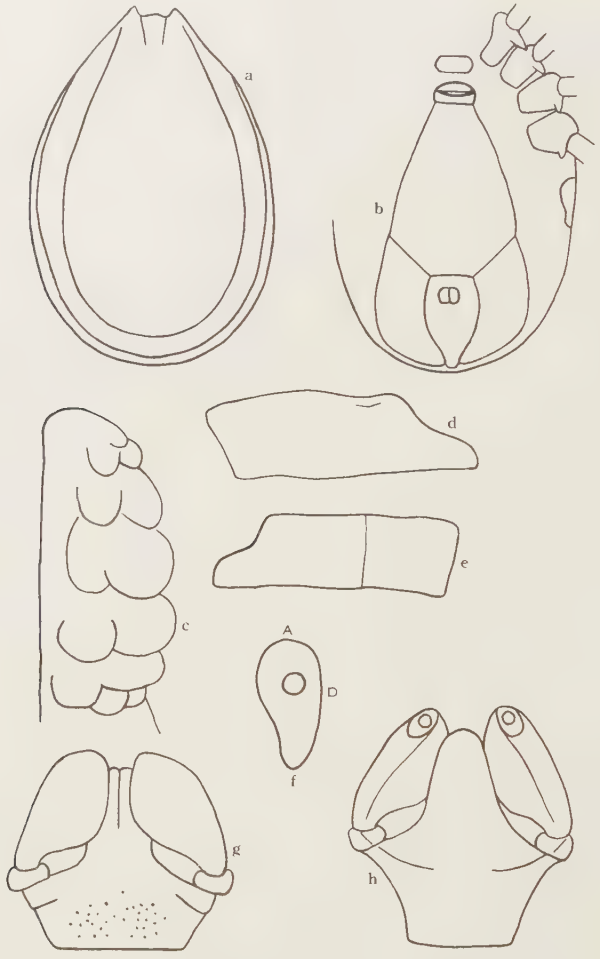

Fig. 35.—*I. cornuatus*, male: *a*, body (dorsal view); *b*, body (ventral view); *c*, hypostome; *d*, tarsus I; *e*, tarsus IV; *f*, spiracular plate; *g*, capitulum (dorsal view); *h*, capitulum (ventral view).

Scutum.—Convex, oval, the lateral grooves well defined and complete; no lateral carinae; punctations fine, scattered, slightly coarser and more numerous anteriorly and laterally; cervical grooves short, shallow, convergent; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of anterior margin of coxa III.

Ventral plates.—Pregenital plate wider than long; median plate widening posteriorly to become a little more than three times its width anteriorly, 2·3 mm by 1·4 mm; anal plate 0·9 by 0·6 mm, the anterior margin straight, bluntly pointed posteriorly at body margin; adanal plates curving posteriorly and inwardly to fuse behind the point of the anal plate; ventral plates, particularly the adanals, with some fine, scattered punctations.

Spiracular plates.—Relatively large, elongate oval, narrower posteriorly, the longer axis directed anteriorly, 0·71 by 0·36 mm, the macula anterior to centre.

Legs.—Length moderate, relatively stout, with many short bristles; coxae contiguous or almost so, each with a row of long hairs near the posterior margin and with an external spur, the spurs decreasing in size posteriorly; trochanters with external, rounded, spur-like protrusion most developed on trochanters II and III, tarsi tapering somewhat abruptly, tarsus I 0·82 mm in length, tarsus IV 0·79 mm in length.

Female

Fig. 36, *a–j*

Diagnosis

A *holocyclus*-like tick with a long capitulum; cornua well defined and bluntly pointed, porose areas deep, large, auriculae strong, palpal article 1 with dorsal and ventral flanges, hypostome lanceolate, dentition mainly 3/3; scutum slightly longer than wide and widest at about mid-length, with strong, lateral carinae; no sternal plate; anal groove closed behind; all coxae with external spurs; tarsi tapering rather abruptly.

Description

Body.—Oval, widest at level of spiracles, 4·7 by 3·3 mm (unfed); marginal grooves well developed and complete; some scattered, pale hairs, more numerous ventrally.

Capitulum.—Long, 1·5 mm; basis dorsally 0·85 mm wide, the lateral fields somewhat swollen, posterior margin sinuous, posterolateral margins divergent anteriorly, cornua well developed and bluntly pointed; porose areas large, broadly oval, deep, the interval depressed and less than the width of one; basis ventrally with strong, blunt auriculae and with faint transverse suture, posterior margin rounded; palpi long and slender, article 1 wider than long, rounded and somewhat salient laterally, with a small, erect, dorsal flange and a more strongly developed keel-like flange ventrally, articles 2 and 3 apparently fused, 1·1 mm in length, narrow at base, the apex rounded, and reaching at mid-length a width of about one-third the length.

Hypostome lanceolate, 0·96 mm in length; bluntly pointed; dentition mainly 3/3, but 2/2 basally and some rows of 4/4 of small teeth distally, file 1 with about 12 large pointed teeth, file 2 with about 10 12 smaller teeth, and file 3 with a number of tiny teeth crowded distally.

Scutum.—Slightly longer than wide, 2·5 by 2·3 mm, and widest at about mid-length, somewhat flat medianly, convex laterally, lateral carinae strong, slightly curved convergently to reach the posterior margin; anterolateral margins and posterolateral margins sinuous, the posterior angle broadly rounded; punctations fine, scattered, somewhat coarser and more numerous in scapular fields; cervical

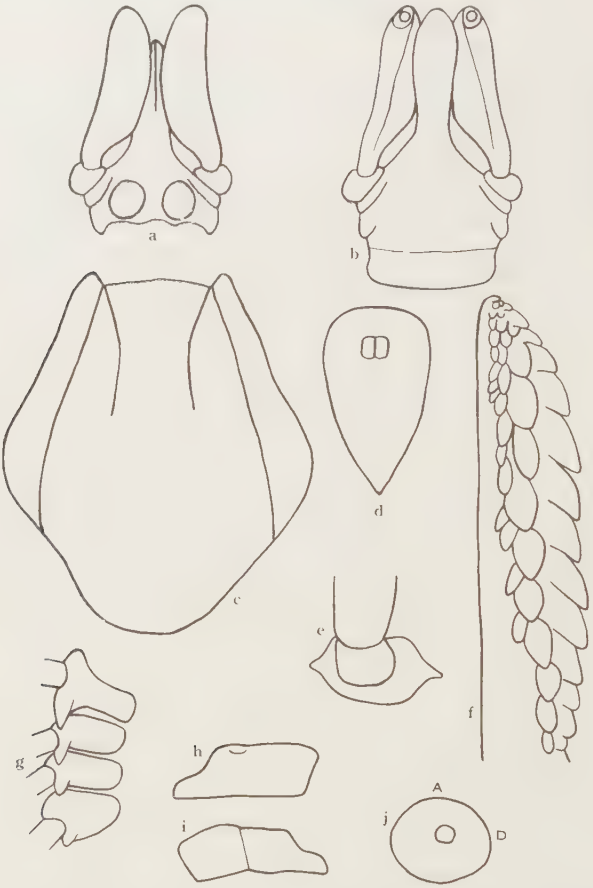

Fig. 36.—*I. cornuatus*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, anal grooves; *e*, palpal article 1 (lateral view); *f*, hypostome; *g*, coxae; *h*, tarsus I; *i*, tarsus IV; *j*, spiracular plate.

grooves well developed anteriorly, at first convergent, then continuing to about mid-scutum as very shallow, divergent depressions; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of coxa IV.

Genital grooves.—Divergent to about level of anus then curved convergently.

Anal groove.—Convex anteriorly and curved posteriorly to meet in an elongate point.

Spiracular plate.—Subcircular and about 0·53 mm in diameter.

Legs.—Relatively long and somewhat stout; coxae flat, each with a row of hairs towards the posterior margin and with well-defined external spurs decreasing in size posteriorly, the spur on coxa I long and blunt; trochanters with external tuberosities, most developed on trochanters II–III; tarsi tapering somewhat abruptly, tarsus I 1·07 mm in length, tarsus IV 0·9 mm in length.

Comments

The paratypes differed little from the type specimens and these differences were only slight and confined to measurements. The male's body measurements were 3·5 by 2·5 mm. In the females, the engorged specimens measured up to 14·3 by 11·0 mm and the scuta of these females varied from 2·5 by 2·2 mm to 2·8 by 2·4 mm. The material available for examination included a female from an unknown host, Nubeena, Tas., 12.x.1948, which was too damaged to be included as a paratype.

Roberts (1954) discussing the distribution of *I. holocyclus* in Victoria noted that the specimens (females) on which his remarks were based were "larger than females from Queensland and New South Wales. Unfed females from these two States measured 2·6 to 3·8 mm in length and their scuta 1·9 by 1·9 mm to 2·3 by 2·2 mm, whereas these measurements for the Victorian specimens were 4·3 to 4·6 mm and 2·5 by 2·4 mm to 2·7 by 2·6 mm respectively." These specimens were from an unknown host, Warragul district, a dog, Warburton, a koala, Sassafras, and from an unknown host, Mt. Buffalo. None of these specimens, unfortunately, were available for re-examination, but the author's recollection of the presence of well-developed cornua places them as *I. cornuatus.*

The presence of an engorged female on a dog suffering from tick paralysis is significant, but further evidence is required before the role of this species in causing this disease can be assessed.

I. cornuatus and *I. holocyclus* are the only two species of *Sternalixodes* in which a sternal plate is absent in the female. The two species, particularly the males, are also very similar in other morphological respects. Measurements are compared in Table 1.

In addition to the well-developed cornua, the female *I. cornuatus* may be distinguished from *I. holocyclus* by the hypostome dentition (see Figs. 30*d* and 36*f*).

Ixodes hirsti Hassall

Ixodes hirsti Hassall, 1931, p. 232. Roberts, 1959, p. 268.

Ixodes victoriensis Hirst, 1930, pp. 575–6 (not *Ixodes victoriensis* Nuttall, 1916, pp. 297–8).

?*Ixodes holocyclus* Schulze, 1935, p. 36, fig. 5 (identity doubtful).

The nymph and larva of this species are unknown.

Male

Fig. 37, *a–f*

Diagnosis

Body oval with narrow marginal body fold; scutum with numerous fine punctations and with complete lateral grooves, appearing as mild carinae anteriorly; capitulum short and broad, dentition 2/2 of shallow, rounded teeth; anal plate bluntly pointed posteriorly; adanal plates curving inwardly to blunt points which fuse posterior to anal plate; coxae I–III with internal and external spurs, coxa IV with a single, small spur; tarsi with mild subapical humps.

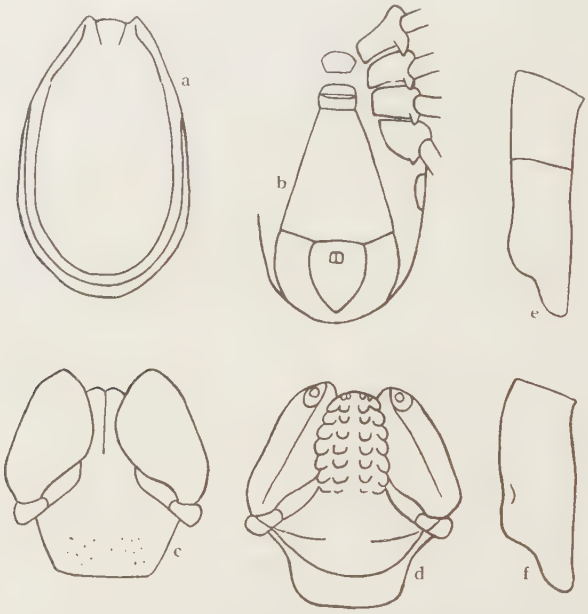

Fig. 37.—*I. hirsti*, male: *a*, body (dorsal view); *b*, body (ventral view); *c*, capitulum (dorsal view); *d*, capitulum (ventral view) with hypostome; *e*, tarsus IV; *f*, tarsus I.

Description

Body.—Oval, 3·0–3·3 mm by 1·7–1·9 mm, widest just posterior to coxa IV, marginal body fold very narrow, a little wider posteriorly; hairs few and scattered dorsally, more numerous ventrally.

Capitulum.—Short and broad, 0·50–0·67 mm in length; basis dorsally with lateral fields somewhat swollen and the median field mildly punctate, 0·4 mm wide, posterior margin straight, posterolateral margins straight and divergent anteriorly, no cornua; basis ventrally with short, obliquely transverse ridges adjacent to palpal insertions; palpi short and broad, article 1 longer externally than internally and ridge-like ventrally, articles 2 and 3 apparently fused, 0·35–0·40 mm in length, very broad, the width at mid-length 0·23 mm.

Hypostome 0·35 mm in length with parallel sides and rounded apex; dentition 2/2 of about 6 rows of rounded teeth with a ridge-like row basally.

Scutum.—Only slightly smaller than body, oval, convex, lateral grooves complete, appearing as mild carinae anteriorly and becoming shallow and progressively wider posteriorly; punctations fine and numerous; cervical grooves short, shallow, convergent; emargination moderate; scapulae blunt.

Genital aperture.—At level of coxa III.

Ventral plates.—Pregenital plate hexagonal, 0·36 by 0·30 mm; median plate 1·46 by 1·00 mm, widest towards the posterior margin; anal plate 0·57 by 0·50 mm, the anterior margin straight or slightly convex, the lateral margins curved convergently posteriorly to form a blunt point; adanal plates with anterior margin straight, curving posteriorly to fuse behind anal plate; punctations on plates scattered.

Spiracular plate.—Elongate oval, narrower posteriorly than anteriorly, the longer axis directed anteriorly, 0·57 mm in length.

Legs.—Length moderate and with hairs longer and denser than on body; coxae almost contiguous, relatively flat, with a row of long hairs near the posterior margins, coxae I–III with mild internal and well-defined external spurs, the internal spur largest on coxa I and about equal in size on coxae II and III, the external spurs becoming progressively smaller posteriorly, coxa IV somewhat triangular, with a single, small, external spur; tarsi with mild subterminal humps, tarsus I 0·66 mm in length, tarsus IV 0·69 mm in length.

Female

Fig. 38, *a–i*

Diagnosis

A large tick when engorged; scutum longer than wide and widest just posterior to mid-length, with strong lateral carinae; capitulum long, the palpi slender, elongate, the basis with well-developed carinae dorsally and ventrally, no cornua, porose areas large, deep, oval, pointed auriculae present, hypostome lanceolate, dentition mainly 3/3, file 3 of small crowded teeth; sternal plate present, elongate triangular; coxae I and II with anteriorly directed ridges, all coxae with an external spur, that on coxa IV much reduced.

Description

Body.—Partly fed specimens 3·4 by 2·8 mm, body broadly oval, semi-engorged specimens frequently widest between coxa IV and spiracles, engorged specimens to 15·4 by 11·4 mm widest in region of anus; marginal grooves well developed and complete, disappearing on engorgement; posterolateral and median grooves well defined; some small, scattered, pale hairs present.

Capitulum.—1·3–1·6 mm in length; basis dorsally 0·78 mm wide, median field depressed and separated from the raised lateral fields by strong carinae which extend from the base of mouthparts to the posterior margin close to the posterolateral angles, the posterior margin a little sinuous, the posterolateral margins straight

or slightly curved and divergent anteriorly, no cornua; basis ventrally with a mildly convex posterior margin and 2 strong carinae which terminate in pointed auriculae: porose areas large, subcircular or broadly oval, deep, almost contiguous with the posterior margin and the carinae, the interval depressed and less than the width of one; palpi long and slender, 1·0–1·2 mm in length, article 1 wider than long,

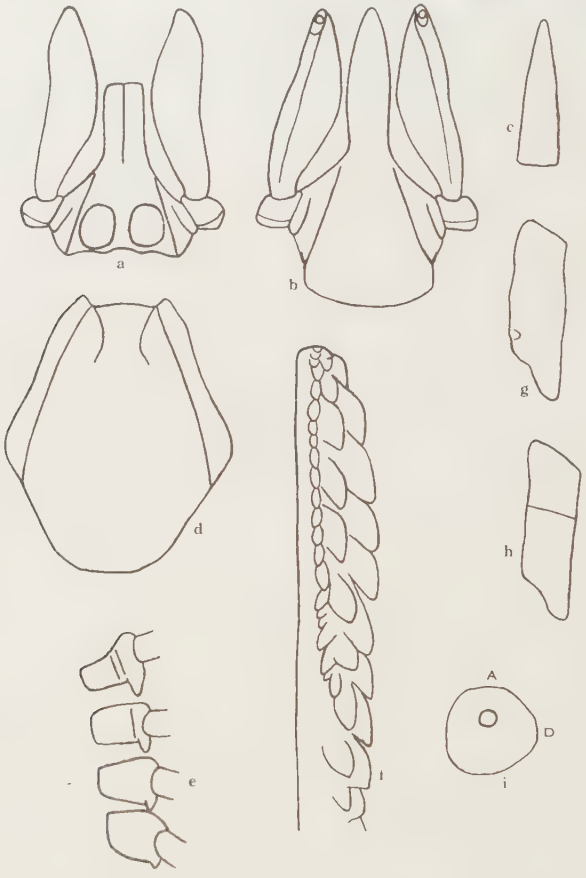

Fig. 38.—*I. hirsti*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, sternal plate; *d*, scutum; *e*, coxae; *f*, hypostome; *g*, tarsus I; *h*, tarsus IV; *i*, spiracular plate.

rounded and somewhat salient laterally, and with a keel-like flange ventrally, articles 2 and 3 apparently fused, narrow at base and distally, and widest just posterior to the mid-length, the greatest width being about one-quarter the length.

Hypostome 0·9–1·0 mm in length, somewhat lanceolate, the apex bluntly pointed: dentition mainly 3/3, 2/2 basally, file 3 composed of about 20 crowded, very small teeth, files 1 and 2 with about 16 teeth, indistinct distally.

Scutum.—Longer than wide, 2·5–2·8 mm by 2·0–2·2 mm and widest just posterior to mid-length, flat medianly, convex laterally; lateral carinae strong and

attaining posterior margin; anterolateral margins sinuous, posterolateral margins a little concave, posterior angle broadly rounded; punctations fine and scattered medianly, more numerous and a little coarser laterally; cervical grooves short and convergent continuing for a short distance posteriorly as divergent, shallow depressions; emargination moderate; scapulae bluntly pointed.

Genital aperture.—Position varying from third intercoxal space to a level with coxa IV; sternal plate somewhat variable in shape, but usually elongate triangular, the apex sometimes a little rounded, length 0·6–0·8 mm, the width at base about one-quarter the length.

Genital grooves.—Divergent posterior to genital aperture, then curving convergently to posterior margin of body.

Anal grooves.—Rounded in front then curving convergently behind to meet at a point.

Spiracular plate.—Subcircular, the longer axis transverse, 0·43–0·50 mm wide.

Legs.—Slender and of moderate length; coxae each with a row of hairs near posterior margin and a moderate external spur which becomes progressively smaller posteriorly, that on coxa IV being relatively inconspicuous, coxae I and II with anteriorly directed ridges; tarsi with mild subapical humps, tarsus I 0·86-0·94 mm in length, tarsus IV 0·84–0·93 mm in length.

Hosts and Distribution

Material examined.—NEW SOUTH WALES: *Wallabia bicolor*, Mt. Irvine, Blue Mountains, 11.vii.1950, 1 ♀; "Tasmanian wallaby", Taronga Park Zoological Gardens, Sydney, 18.viii.1927, 1 ♀; *Rattus assimilis*, Colo Vale, 22.i.1957, 1 ♀. VICTORIA: *Felis catis*, Selby, 6.xi.1957, 1 ♀; *Phascolarctos cinereus*, Sassafras, 6.ii.1951, 2 ♀♀; Cape Otway, 29.xi.1951, 2 ♂♂ (damaged), 12 ♀♀; Cape Otway, 29.i.1932, 1 ♂; *Wallabia bicolor*, Lower Tarwin, 24.xi.1925, 1 ♂, 2 ♀♀. TASMANIA: "kangaroo", King I., 2.x.1935, 1 ♀; Mt. Wellington, 15.xi.1937, 1 ♀. Hirst (1930) has recorded this species also from *Pseudocheirus peregrinus*, Lower Tarwin, Vic.

Comments

This species was originally described by Hirst (1930) as *I. victoriensis*, the name being subsequently changed by Hassall (1931) to *I. hirsti*, as it was preoccupied by Nuttall's (1916) *I. victoriensis* from the wombat.

The description of this species by the author agrees closely with the salient features noted by Hirst (1930).

Of the five species of *Sternalixodes*, *I. hirsti* is closest to *I. confusus*. In the males of both species the lateral grooves appear anteriorly as mild carinae, but in the male of *I. confusus* these grooves are interrupted to reappear posteriorly, whereas in *I. hirsti* they are continuous, although shallow. In *I. confusus* also, the trochanters in the male are armed, whereas in *I. hirsti* trochantal spurs are absent. The females in both species possess coxae with longitudinal ridges and can be separated by this character from the females of *I. cornuatus*, *I. holocyclus*, and *I. trichosuri*. In this sex also, the basis ventrally has 3 carinae in *I. confusus* and only 2 in *I. hirsti* and in the former also the trochanters are spurred, whereas in the latter spurs are absent. The species determined and figured by Schulze (1935) as *I. holocyclus* could be *I. hirsti*.

Ixodes trichosuri, sp. nov.

Holotype.—♂, bred from a nymph, Beecroft, N.S.W., 17.xi.1955, M. D. Murray, in the Australian Museum. Host of nymph: *Trichosurus vulpecula.*

Allotype.—♀ (partly engorged), same data as holotype, in the Australian Museum.

Paratypes.—1 ♂, same data as holotype but dated July 1955; 1 ♂, 1 ♀ (engorged), Beecroft, October 1955, M. D. Murray, *T. vulpecula.* The following paratypes were collected by M. D. Murray at Cheltenham, N.S.W., from the same host: 1 ♀ (engorged), 8.vii.1955; 1 ♀ (engorged), 20.xii.1955; 1 ♂, reared from nymph, 24.vi.1955; 3 ♀♀ (engorged), 17.v.1955; 4 ♀♀ (engorged), 14.xii.1955; 1 ♀ (engorged), 24.vii.1955; 1 ♀ (engorged), 29.vii.1955; 1 ♀ (engorged), 8.vi.1955.

The paratypes have been distributed between the Queensland Museum, the Australian Museum, Sydney, the National Museum of Victoria, Melbourne, and the author's collection.

Male

Fig. 39, *a–f*

Diagnosis

Body oval with a very narrow marginal fold; scutum with triangular depressions in anterolateral fields and a subcircular depression medianly; punctations fine, numerous; lateral grooves apparent posteriorly only; capitulum short, basis dorsally punctate, palpi broad and short; median plate almost as broad as long; anal plate pointed behind; coxae I–III with 2 spurs, the external well developed, the internal small and indistinct, coxa IV with 1 small spur; tarsi tapering gradually.

Description

Body.—Oval, 3·17 by 2·10 mm, widest in region of spiracles; marginal body fold very narrow widening a little posteriorly; hairs minute, few, and scattered, some longer hairs ventrally.

Capitulum.—Short, 0·54 mm in length; basis dorsally 0·37 mm wide, medianly depressed and punctate, posterior margin straight, posterolateral margins straight and divergent anteriorly, posterolateral angles reasonably sharp, no cornua; basis ventrally with 2 short ridges adjacent to insertion of palpi; palpi short and broad, article 1 salient laterally, wider than long and ventrally with an anteroposterior keel-like flange in line with ridges on basis, articles 2 and 3 apparently fused, about 0·33 mm in length, and with a maximum width of about 0·23 mm.

Hypostome about 0·23 mm in length, dentition 2/2, of 4 rows of large, rounded teeth, a few minute, rounded teeth distally, and 2 rows of shallow ridge-like teeth basally.

Scutum.—Almost equal in size to body, convex with several depressions, the most obvious being a median subcircular depression and 2 less-distinct, elongate, triangular depressions extending from scapulae for about half the length, no apparent carinae, lateral grooves shallow and visible posteriorly only; punctations fine, very

numerous and close together giving scutum a mildly rugose appearance; cervical grooves very short and shallow; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of coxa III.

Ventral plates.—Pregenital plate, smooth, hexagonal, much wider than long, 0·40 by 0·23 mm, median plate 1·4 by 1·2 mm, its greatest width about four times its width at the anterior margin; anal plate pyriform, pointed behind, the anterior margin a little convex, 0·70 by 0·57 mm; adanal plates curving posteriorly to points which extend to the point of the anal plate; punctations absent on median plate, scattered on adanal and anal plates.

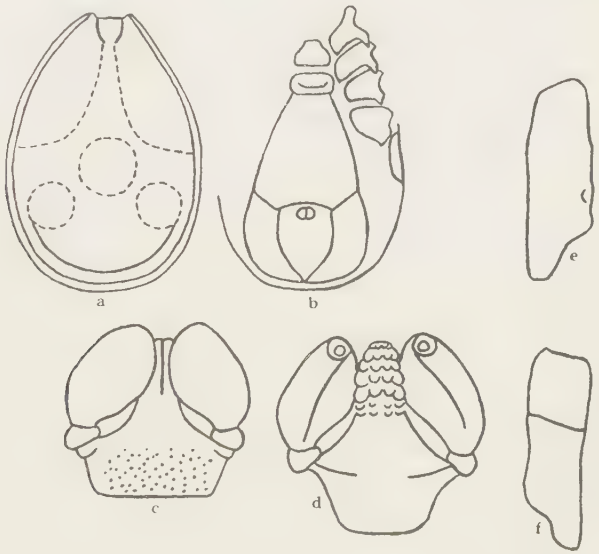

Fig. 39.—*I. trichosuri*, male: *a*, body (dorsal view); *b*, body (ventral view); *c*, capitulum (dorsal view); *d*, capitulum (ventral view); *e*, tarsus I; *f*, tarsus IV.

Spiracular plate.—Oval, 0·52 mm in length, the longer axis directed anteriorly.

Legs.—Of moderate length and with numerous bristle-like hairs; coxae almost contiguous, a little convex and with a row of long hairs near the posterior margins; coxae I–III with 2 spurs, the external spurs well developed, the internal spurs especially on coxae II and III somewhat indistinct, coxa IV with a single, small, external spur; tarsi tapering gradually, tarsi I and IV 0·6 mm in length.

Female

Fig. 40, *a–i*

Diagnosis

Scutum a little longer than wide, with strong carinae; capitulum long, no cornua, dorsum and venter of basis with carinae; porose areas large, oval, interval very narrow; hypostome acutely pointed, dentition mainly 3/3; sternal plate

present; coxae with a row of long hairs, and each with an external spur; anal grooves meeting at a point behind, tarsi terminating gradually.

Description

Body.—Partly fed specimen pyriform, 3·2 by 2·4 mm, widest in region of spiracles, marginal grooves seen laterally only; hairs few, practically glabrous dorsally, and ventrally mainly in posterolateral regions.

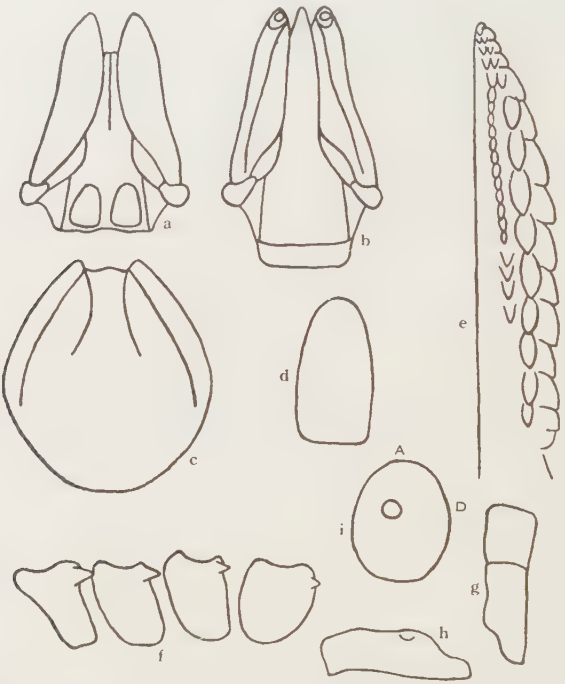

Fig. 40.—*I. trichosuri*, female: *a*, capitulum (dorsal view); *b*, capitulum (ventral view); *c*, scutum; *d*, sternal plate; *e*, hypostome; *f*, coxae; *g*, tarsus IV; *h*, tarsus I; *i*, spiracular plate.

Capitulum.—1·14 mm in length; basis dorsally 0·64 mm wide, posterior margin slightly sinuous, a little elevated medianly, posterolateral margins slightly curved and divergent anteriorly, no cornua, prominent carinae on each side extending from base of mouthparts to posterolateral angles; porose areas large, deep, pear-shaped, the longer axis directed anteriorly, contiguous with carina and almost so with posterior margin, interval very narrow, less than half the width of one and elevated; basis ventrally with posterior margin rounded, median field depressed, lateral fields raised and separated from median field by prominent carinae extending to a well-defined, transverse suture, no auriculae; palpi long and slender, article 1 rounded and salient laterally, dorsally and ventrally with a transverse flange, articles 2 and 3 apparently fused, 0·86 mm in length and with a maximum width of 0·29 mm.

Hypostome 0·62 mm in length, lanceolate and rather acutely pointed; dentition mainly 3/3, 2/2 basally, distal teeth very minute, files 1 and 2 with about 12 large, obvious teeth, those in file 2 smaller than those in file 1, file 3 with about 20 small, crowded teeth.

Scutum.—Longer than wide, 2·2 by 1·9 mm, widest a little posterior to mid-length, median field flat and delimited from convex lateral fields by strong carinae; anterolateral margins divergent, convex, posterolateral margins convex, posterior angle broadly rounded; punctations fine, fairly numerous and scattered, a little coarser in scapular fields and along posterior margin; cervical grooves short, and shallow, continuing for a short distance posteriorly as divergent very superficial depressions; emargination moderate; scapulae bluntly pointed.

Genital aperture.—At level of coxa IV; sternal plate oval, the sides gently curved, 0·69 by 0·33 mm.

Genital grooves.—Divergent to about level of anus then curving convergently to the posterior body margin.

Anal grooves.—Broadly pyriform and meeting in a point behind anus.

Spiracular plate.—Broadly oval, 0·50 by 0·43 mm, the longer axis directed anteriorly, macula eccentric.

Legs.—Length moderate, numerous bristle-like hairs ventrally; coxae with surface a little convex and with a row of long hairs along posterior margin, all coxae with an external blunt spur, decreasing in size posteriorly to become relatively indistinct on coxa IV; tarsus I terminating obliquely, other tarsi a little more abruptly, tarsus I about 0·68 mm and tarsus IV about 0·60 mm in length.

Nymph

Fig. 41, *h–i*

Diagnosis

Capitulum generally similar to that of female, but with transverse suture as a ridge terminating in mild auricular-like processes; hypostome acutely pointed, dentition 2/2; shape of scutum as in female, but a little wider than long and with emargination almost obsolete; sternal plate oval; coxae I–IV with an external spur, that on coxa IV very minute; anal grooves closed posteriorly.

Description

Body.—Oval, partly engorged 1·0 by 0·7 mm, fully engorged 3·6 by 2·6 mm: marginal grooves visible laterally only; practically glabrous.

Capitulum.—Length 0·4 mm; basis dorsally 0·23 mm wide, rectangular, the posterior margin straight and a little elevated, the lateral margins straight and divergent anteriorly, basis ventrally with the transverse suture as a ridge terminating laterally in rounded auricular-like processes, posterior margin rounded and relatively narrow; palpi as in female, articles 2 and 3 about 0·32 mm in length.

Hypostome 0·3 mm in length, acutely pointed; dentition 2/2 of about 16 teeth, both files well developed.

Scutum.—Shape as in female, but a little wider than long and with emargination practically obsolete and scapulae shallow and rounded; dimensions 0·57–0·61 mm by 0·63–0·71 mm; lateral carinae well developed, surface granulated, punctations few, fine, and scattered.

Sternal plate.—Oval, 0·26 by 0·14 mm.

Anal grooves.—Meeting at a point posteriorly.

Spiracular plate.—Circular, 0·13 mm in diameter.

Legs.—Coxae I–IV each with an external spur, that on coxa IV very minute; tarsi tapering obliquely, tarsi I and IV about 0·29 mm in length.

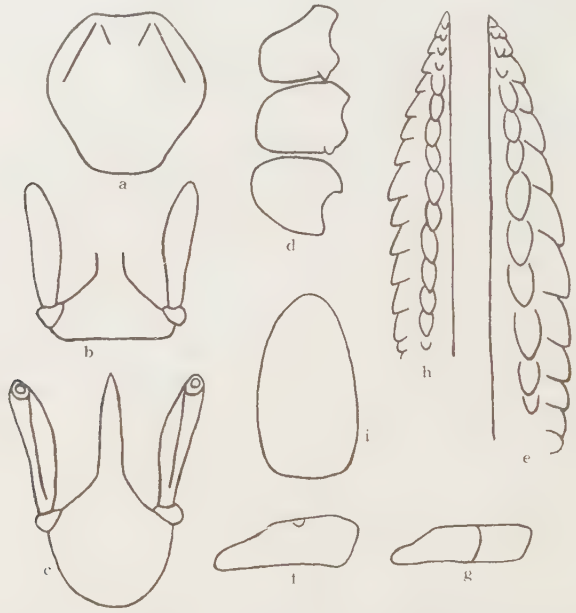

Fig. 41.—*I. trichosuri*, larva (*a–g*) and nymph (*h*, *i*): *a*, scutum; *b*, capitulum (dorsal view); *c*, capitulum (ventral view); *d*, coxae; *e*, hypostome; *f*, tarsus I; *g*, tarsus IV; *h*, hypostome; *i*, sternal plate.

Larva

Fig. 41, *a–g*

Diagnosis

Capitulum long, slender, hypostome acutely pointed, dentition 2/2; scutum about as wide as long, with faint lateral carinae, emargination almost obsolete, coxae I and II each with a small, external spur, coxa III unarmed.

Description

Body.—Newly hatched larva globular, 0·45 by 0·43 mm.

Capitulum.—Length 0·21 mm; basis dorsally triangular, 0·11 mm in width, posterior margin straight; basis ventrally with strongly rounded posterior margin,

2 pairs of bristles present; palpi long and slender, 0·2 mm in length, articles 2 and 3 about 0·03 mm in maximum width.

Hypostome acutely pointed, 0·17 mm in length, dentition 2/2 of about 14 teeth, the outer file with strongly developed pointed teeth.

Scutum.—About as wide as long, 0·31 by 0·32 mm; surface convex, finely granulated; anterolateral margins slightly convex, posterolateral margins mildly concave, posterior angle broadly rounded; faint lateral carinae; cervical grooves indistinct, short, shallow; emargination very shallow, almost obsolete; scapulae shallow, rounded.

Anal grooves.—Not apparent.

Legs.—Coxae contiguous, coxae I and II with a small, external spur, coxa III unarmed; tarsi tapering gradually, tarsi I and IV about 0·17 mm in length.

Comments

The material on which the description of this new species is based was collected from the brush-tailed possum, *Trichosurus vulpecula*, at Beecroft and Cheltenham, both of which are suburbs of Sydney. The collection was made by Mr. M. D. Murray, McMaster Laboratory, C.S.I.R.O., who, although he recognized a new species was involved, kindly made it available for this revision.

The paratype males agree substantially with the description of the holotype and this sex can be readily distinguished from the known males of other Australian *Sternalixodes* by the absence of lateral carinae and by the lateral grooves which are shallow and visible posteriorly only.

The paratype females are all engorged specimens and measured up to 15·5 by 11·0 mm. They also agree closely with the allotype, but the porose areas are oval to subcircular in some specimens. In the engorged specimens the lateral grooves were not apparent. The acutely pointed hypostome, the dentition, the shape of the scutum, the presence of a sternal plate, and the smooth coxae readily distinguish the female of *I. trichosuri* from females of *I. holocyclus*, *I. hirsti*, *I. cornuatus*, and *I. confusus*.

Of the species of *Sternalixodes* the nymphs and larvae are known only for *I. holocyclus* and *I. trichosuri*. The acutely pointed hypostome readily distinguishes these stages in *I. trichosuri*. The shape of the scutum of the larva of *I. trichosuri* and the absence of a spur on coxa III are also valuable in diagnosis.

Host–Parasite List

Classification and Name of Host	Parasite
MONOTREMATA	
Ornithorhynchidae	
Ornithorhynchus anatinus (Shaw & Nodder, 1799), platypus	*I. ornithorhynchus*
MARSUPIALIA	
Dasyuridae	
Antechinus flavipes (Waterhouse, 1838), yellow-footed marsupial mouse	*I. antechini* *I. fecialis* *I. holocyclus* *I. tasmani*

Classification and Name of Host	Parasite
Antechinus sp.	*I. fecialis*
Phascogale tapoatafa (Meyer, 1793), brush-tailed marsupial rat	*I. holocyclus*
Marsupial rat	*I. tasmani*
Sminthopsis crassicaudata (Gould, 1844), fat-tailed marsupial mouse	*I. fecialis*
S. murina (Waterhouse, 1838), grey marsupial mouse	*I. antechini*
Dasyurus quoll (Zimmerman, 1777), eastern native cat	*I. fecialis*
D. geoffroyii (Gould, 1841), western native cat	*I. fecialis*
Dasyurops maculatus (Kerr, 1792), tiger cat	*I. tasmani*
Native cat	*I. fecialis* *I. tasmani*
Sarcophilus harrisii (Boitard, 1841), Tasmanian devil	*I. tasmani*
Myrmecobiidae	
Myrmecobius fasciatus Waterhouse, 1836, banded ant-eater	*I. fecialis* *I. vestitus*
Peramelidae	
Isoodon obesulus (Shaw & Nodder, 1797), short-nosed bandicoot	*I. fecialis* *I. holocyclus* *I. tasmani*
I. torosus (Ramsay, 1877), giant brindled bandicoot	*I. holocyclus*
Perameles nasuta Geoffroy, 1804, long-nosed bandicoot	*I. holocyclus*
Perameles sp.	*I. fecialis*
Bandicoot	*I. holocyclus* *I. tasmani* *I. fecialis*
Phalangeridae	
Pseudocheirus peregrinus (Boddaert, 1785), ring-tail possum	*I. hirsti*
P. laniginosus (Gould, 1858), south-eastern ring-tail possum	*I. tasmani*
Pseudocheirus sp.	*I. tasmani*
Petaurus sp., glider	*I. tasmani*
Schoinobates volans (Kerr, 1792), greater glider	*I. tasmani*
Trichosurus vulpecula (Kerr, 1792), brush-tailed possum	*I. holocyclus* *I. tasmani* *I. trichosuri*
Trichosurus sp.	*I. tasmani*
Possum	*I. holocyclus* *I. tasmani* *I. fecialis*
Phascolarctidae	
Phascolarctos cinereus Goldfuss, 1817, koala	*I. cornuatus* *I. holocyclus* *I. hirsti* *I. tasmani*
Vombatidae	
Vombatus hirsutus (Perry, 1810), common wombat	*I. victoriensis*
Wombat	*I. tasmani* *I. victoriensis*

Classification and Name of Host	Parasite
Macropodidae	
Bettongia leseur (Quoy & Gaimard, 1824), rat-kangaroo	*I. australiensis*
B. penicillata Gray, 1837, brush-tailed rat-kangaroo	*I. australiensis*
Dendrolagus lumholtzi Collett, 1884, tree kangaroo	*I. holocyclus*
Protemnodon bicolor (Desmarest, 1804), black-tailed wallaby	*I. holocyclus* *I. hirsti*
Protemnodon sp.	*I. tasmani*
Setonix brachyurus (Quoy & Gaimard, 1830), quokka	*I. australiensis*
Macropus spp. (unidentified kangaroos and wallabies)	*I. cornuatus* *I. hirsti* *I. australiensis* *I. holocyclus* *I. fecialis*
LAGOMORPHA	
Leporidae	
Oryctolagus cuniculus (Linnaeus, 1758), wild rabbit	*I. holocyclus* *I. tasmani*
RODENTIA	
Muridae	
Hydromys chrysogaster Geoffroy, 1804, eastern water-rat	*I. holocyclus* *I. tasmani*
H. fuliginosus Gould, 1853, western water-rat	*I. tasmani* *I. hydromyidis*
Rattus assimilis (Gould, 1858), allied rat	*I. fecialis* *I. holocyclus* *I. tasmani* *I. hirsti*
R. conatus Thomas, 1923, dusky field-rat	*I. fecialis* *I. holocyclus*
R. calmorum	*I. fecialis*
R. rattus (Linnaeus, 1758), black rat	*I. fecialis* *I. hydromyidis* *I. holocyclus*
R. norvegicus (Berkenhout, 1769), brown rat	*I. holocyclus* *I. tasmani*
Rattus sp.	*I. tasmani* *I. hydromyidis*
Mus musculus Linnaeus, 1758, house mouse	*I. holocyclus*
Mus sp.	*I. fecialis*
Conilurus albipes (Lichtenstein, 1829), white-footed rabbit-rat	*I. tasmani*
Rabbit-rat	*I. tasmani*
Melomys cervinipes (Gould, 1852), scale-tailed tree-rat	*I. holocyclus* *I. tasmani*
M. littoralis (Lönnberg, 1916), little tree-rat	*I. holocyclus*

Classification and Name of Host	Parasite
Uromys caudimaculatus (Krepft, 1867), giant scale-tailed rat	*I. holocyclus*
Uromys sp.	*I. tasmani*
	I. holocyclus
CARNIVORA	
Felidae	
Felis catus Linnaeus, 1758, cat	*I. fecialis*
	I. holocyclus
	I. hirsti
	I. tasmani
	I. cornuatus
Canidae	
Canis familiaris Linnaeus, 1758, dog	*I. cornuatus*
	I. holocyclus
	I. tasmani
	I. australiensis
C. dingo Meyer, 1793, dingo	*I. holocyclus*
Canis sp.	*I. australiensis*
CHIROPTERA	
Vespertilionidae	
Miniopterus schreibersii blepotis (Temminck, 1840), bent-winged bat	*I. simplex simplex*
	I. vespertilionis
Bat	*I. vespertilionis*
	I. simplex simplex
ARTIODACTYLA	
Suidae	
Sus scrofa Linnaeus, 1758, pig	*I. holocyclus*
Bovidae	
Bos taurus Linnaeus, 1758, ox	*I. holocyclus*
	I. australiensis
Ovis aries Linnaeus, 1758, sheep	*I. holocyclus*
Capra hircus Linnaeus, 1758, goat	*I. holocyclus*
PERISSODACTYLA	
Equidae	
Equus caballus Linnaeus, 1758, horse	*I. holocyclus*
	I. tasmani
PRIMATES	
Hominidae	
Homo sapiens Linnaeus, 1758, man	*I. holocyclus*
	I. tasmani
	I. confusus
	I. kohlsi
OPHIDIA	
Colubridae	
Demansia textilis (Dumeril & Bibron, 1854), brown snake	*I. vestitus*
LACERTILIA	
Scincidae	
Tiliqua scincoides (Shaw, 1790), blue-tongue lizard	*I. ornithorhynchi*
PELECANIFORMES	
Phalacrocoracidae	
Phalacrocorax fuscescens (Vieillot, 1817), cormorant	*I. kohlsi*

Classification and Name of Host	Parasite
SPHENISCIFORMES	
Spheniscidae	
Eudyptula minor (Forster, 1781), little penguin	*I. kohlsi* *I. eudyptidis* *I. rothschildi*
Eudyptula sp.	*I. kohlsi* *I. uriae* ?*I. eudyptidis*
PASSERIFORMES	
Pittadae	
Pitta sp., dragoon bird	*I. holocyclus*
Sylviidae	
Pycnoptilus floccosus Gould, 1851, pilot bird	*Ixodes* sp. (nymph)
Corvidae	
Corvus coronoides (Vigors & Horsefield, 1827), raven	*I. holocyclus*
Acanthizidae	
Sericornis frontalis (Vigors & Horsefield, 1827), scrub wren	*Ixodes* sp. (larva)
PROCELLARIIFORMES	
Diomedeidae	
Diomedia exulans Linnaeus, 1758, wandering albatross	*I. pterodromae* *I. uriae*
Procellariidae	
Puffinus tenuirostris (Temminck, 1835), Tasmanian mutton-bird	*I. kohlsi* (in nests)

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List of Species

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